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TESI DI DOTTORATO DI RICERCA

The deployment of blockchain technology in the logistics and shipping industry: possible outcomes and need of uniform regulation

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INTRODUCTION

At the beginning of this research project, blockchain 'fever' was at its highest all around the world[1].

Born several years before as the technical ground of the famous (or, perhaps, infamous) Bitcoin[2] with the aim to create a financial system capable of by-passing commercial financial institutions and central banks, blockchain had gradually become a buzzword, shaping many sectors of human conduct in a wider process of digitalisation, which is currently testing legal systems and society at large.

Indeed, scholars have already observed[3] that advances in artificial intelligence (AI), biotechnology and distributed ledger technologies (such as blockchains) are changing existing social patterns thereby putting considerable pressure on the *status quo* of well-established legal institutions and arrangements.

In this context, the interest in multifunctional implementations of blockchain technology has risen exponentially during the three-years period of development of the research project, and this mainly because such a disruptive innovation is – by design – a global and transnational tool[4], acting in a fully decentralized system governed by protocols and other code-based rules that are automatically executed by the network itself, potentially without the need for intermediaries. In other terms, blockchains tend to create autonomous and self-regulating systems that have been qualified – maybe in excessively emphatic

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[1] Between January and May 2018 blockchain startups raised more than 1.3 billion in venture capital (*The Economist*, Vol. 428, Iss. 9107, September 1, 2018).

[2] KIVIAT T., *Beyond Bitcoin: Issues in Regulating Blockchain Transactions*, in *Duke Law Journal*, 2015, 65, p. 569; NAKAMOTO S., *Bitcoin: a peer-to-peer electronic cash system*, 2008, https://bitcoin.org/bitcoin.pdf.

[3] DIMITROPOULOS G., *The Law of blockchain*, in *Washington Law Review*, 2020, 95 (3), p. 1117.

[4] DIMITROPOULOS G., *The Law of blockchain*, cit, p. 1119; DE FILIPPI P., HASSAN S., *Blockchain Technology: from Code is Law to Law is Code*, in *First Monday*, December 5, 2016.

terms – as '*the strongest challenge ever posed to the monopoly of the state over the promulgation, formation, keeping a verification of institutions and the public record*'[5].

That being said, the purpose of the research project is to move from the pure theoretical vision pointed out above to a more concrete and practical one, aimed at understanding how legislators and policymakers have to deal with this new technology, its main features and the underlying revolutionary idea of a system of protocols and technical services that potentially have the capacity to implement their own rules running on an artificial network with the aim of pushing national and international laws to the edge.

In doing so, it has been assumed as crucial to analyse how the spread of blockchain can affect our society and the relevant legal relationships among individuals in the logistics and shipping industry, *i.e.* one of the sectors of economy which is making the greatest efforts to embrace such a 'revolution'.

In this context, two possible approaches[6] appear to be available: on the one hand, the yearning for a 'self-restraint' regulation in which the legislator limits his activity in the way deemed sufficient to preserve and protect both technological innovation and the development of a system which creates order without law (the so-called *lex cryptographica*[7]); on the other hand, a 'regulatory presence' approach, aimed at accompanying functionalities of this new rising technology and at boosting an interaction between the 'real world' and 'the online world', through the creation of a *blockchain law*[8] which might act as the

[5] MARKEY-TOWLER B., *Anarchy Blockchain and Utopia: A theory of political-socioeconomic systems organized using blockchain*, in *The Journal of British Blockchain Association*, 2018, 1, pp. 1-14.

[6] CAPPIELLO B., CARULLO G., *Introduction: The Challenges and Opportunities of Blockchain Technologies*, in CAPPIELLO B., CARULLO G. (eds.), *Blockchain*, *Law and Governance*, Berlin, 2020, p. 1.

[7] DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, London, 2019, p. 5.

[8] BLEMUS S., *Law and Blockchain: A Legal Perspective on Current Regulatory Trends Worldwide*, in *Revue Trimestrielle De Droit Financier*, 2017, 4, p. 1; DIMITROPOULOS G., *Blockchain Law: between Public and Private, Transnational and Domestic*, in TRIDIMAS T., DUROVIC M. (eds.), *New Directions in European Private Law*, Oxford, 2020; DIMITROPOULOS G., *The Law of blockchain*, cit., p. 1123;

flip side of the coin with regards to the abovementioned *lex cryptographica*. In this sense, legal and regulatory measures can be the main instruments to prevent the rise of the so-called 'crypto-anarchy'[9] envisioned by the alleged creators of pure decentralised technological systems and, then, to finally allow blockchain technology to be applied in industries.

The aim of this paper is to critically evaluate both the approaches mentioned above and to explore the possible influence thereof on the practical implementation of blockchain technology in every-day life. Generally speaking, and as it will be argued in the following paragraphs, I believe that the truth probably lies somewhere in between and – as it has already been stated by scholars – '*it involves concessions*'[10]: for the law, it means that one should not use the full enforcement arsenal in all circumstances and the legal constraints should be adapted to technology (e.g. by creating legal comfort zones with regulatory sandboxes and safe harbours aimed at studying the impact of blockchain on some specific industries); for technology, it implies that it must be law-oriented.

In this vein, the crucial and barycentric importance of tailoring a new role for the 'ordinary' law in its interaction with the *lex cryptographica* shall be duly explored and stressed in order to create a proper '*law of blockchain*' which may (i) bridge the gap between the technology and the real landscape in which it would be supposed to operate; (ii) enable distributed ledgers to find a proper and functional use and, therefore, (iii) allow for trust in the blockchain not only by

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QUINTAIS J.P., BODÒ B., GIANNOPOULOU A., FERRARI V., *Blockchain and the Law: A Critical Evaluation*, in *Stanford Journal of Blockchain Law & Policy*, 2019, 2 (1), p. 86.

[9] MAY T., *The Cyphernomicon*, 1994, available at https://nakamotoinstitute.org/static/docs/cyphernomicon.txt; HUGES, *Cypherpunk's Manifesto*, 1997, available at https://dl.acm.org/doi/10.5555/285692.285725; NAKAMOTO S., *Bitcoin: a peer-to-peer electronic cash system*, cit.

[10] SCHREPEL T., *Foeword*, in CAPPIELLO B., CARULLO G. (eds.), *Blockchain*, *Law and Governance*, cit., p. vi.

single 'nodes' in the online world but, rather, by all the people living in the real, 'physical', world.

Achieving such a goal is paramount if we wish to prevent all the evocative promises of a '*blockchain revolution*'[11] on real life from boiling down to what William Shakespeare defined as '*Much ado about nothing*'.

In doing so, the logistics and shipping industry undoubtedly constitutes a useful and interesting role model.

As discussed in further hereafter, this is principally due

firstly, to the need by the maritime industry to find innovative ways of remaining competitive in a fast-changing world (especially after the recent and disruptive outbreak of Covid-19 pandemic[12]) while still addressing such longstanding concerns as intensive paperwork, tedious processes and data transparency[13];

secondly, to the potential that blockchain technology hold in addressing industry concerns regarding trust among operators, data integrity, traceability, timeliness ad transparency[14];

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[11] BAVASSANO G., FERRARI C., TEI A., *Blockchain: How shipping industry is dealing with the ultimate technological leap*, in *Research in Transportation Business and Management*, 2020, p. 34.

[12] See UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT (UNCTAD), *Review of Maritime Transport 2020*, available at https://unctad.org/webflyer/review-maritime-transport-2020; TRADE FINANCE GLOBAL AND WORLD TRADE ORGANIZATION, *Blockchain and DLT in Trade: where do we stand?*, November 2020, available at https://www.wto.org/english/res_e/publications_e/blockchainanddlt_e.htm.

[13] PU S., SIU LEE LAM J., *Blockchain adoptions in the maritime industry: a conceptual framework*, in *Maritime Policy and Management*, 2020, 47, p. 1.

[14] DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit., p. 130 ss.

thirdly, to several underlying analogies that such a distributed ledger shares with the ancestors of the documents that still govern maritime shipments and any related contractual relationships[15].

In this vein, the research project has been carried out with a multidisciplinary approach, which nevertheless allows to sketch some conclusion *de iure condendo* on the issues indicated above.

Nevertheless, before moving to a more in-depth analyses of the issues just sketched, a preliminary important preliminary *caveat* must be pointed out, which is the still experimental application of blockchain in the world of logistics and shipping, mainly due to the highly dynamic nature of such a technology.

This made the research more complex on the one hand, but certainly fascinating on the other, given the need to deal with the extremely dynamic and constantly evolving nature of the features and findings that will be illustrated later in this paper.

[15] MUNARI F., *Blockchain and smart contracts in shipping and transport. A legal revolution is about to arrive?*, in SOYER B., TETTENBORN A. (eds.), *New Technologies, Artificial Intellingence and Shipping Law in the 21st Century*, London, 2019, p. 3.

'The blockchain is ultimately about solving society ultimate challenge: trust. Or rather lack of trust'

(A.R. SORKIN, *Demystifying the Blockchain*, *New York Times*, June 27, 2018*)*

1. SOME PRELIMINARY REMARKS ON THE TECHNOLOGY

SUMMARY: 1.1 Blockchain technology in pills: five essential assumptions – 1.2 From permissionless to permissioned blockchain – 1.3 Blockchain generations: an overview – 1.4 The rise of *Lex cryptographica* – 1.5 Challenges yet to be faced by blockchain technology for its widespread diffusion

At their core, blockchains have been defined as '*decentralised databases, maintained by a distributed network of computers. They blend together a variety of different technologies – including peer-to-peer networks, public private key cryptography, and consensus mechanism – to create a novel type of database*'[16].

This being said, the starting point of any possible study of such a potential 'game changer' in our everyday life preliminarily requires a technical understanding of the so-called distributed ledger technologies ('DLT') to fully grasp, on the one hand, their potential and, on the other hand, the issues that these new tools bring along. Thus, in the recent years Institutions[17], scholars[18],

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[16] DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 13 ss.

[17] EUROPEAN COMMISSION, *Blockchain now and tomorrow - Assessing multidimensional impacts of distributed ledger technologies*, 2019, available at https://ec.europa.eu/jrc/en/facts4eufuture/blockchain-now-and-tomorrow; INTERNATIONAL CENTRE FOR TRADE AND SUSTAINABLE DEVELOPMENT, *Maximizing the Opportunities of the Internet for International Trade*, 2016, available at http://www3.weforum.org/docs/E15/WEF_Digital_Trade_report_2015_1401.pdf; UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE (UNECE), *White Paper on Blockchain in Trade Facilitation – Version 2*, 2020, available at http://www.unece.org/fileadmin/DAM/cefact/GuidanceMaterials/WhitePaperBlockchain.pdf.

[18] ARTZT M., RICHTER T. (eds.), *Handbook of Blockchain Law: a guide to understanding and resolving the legal challenges of blockchain technology*, Alphen aan den Rijn, 2020; ATTARAN M., GUNASEKARAN A., *Applications of Blockchain technology in Business – Challenges and Opportunities*, London, 2019; BOREIKO D., FERRARINI G., GIUDICI P., *Blockchain Startups and Prospectus Regulation*, in *European Business Organization Law Review*, 2019, 20, p. 665; CUCCURRU P., *Blockchain ed automazione contrattuale. Riflessioni sugli smart contract*, in *Nuova Giurisprudenza Civile*, 2017, 1, p. 107; DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 13 ss; KRAUS D., OBRIST T., HARI O., *Blockchains, Smart Contracts, Decentralised Autonomous Organisations and the Law*, Cheltenham, 2019; PRIETO MUNOZ J. G., VITERBO A., ODDENINO A., *International Economic Law in the Era of Distributed Ledger Technology*, in *Global Jurist,* 2020, p. 20; SZOSTEK

engineers, economists, market operators, as well as lawyers[19] and sociologists, tried their hand at drawing up 'practical handbooks' on all the key technological components that are involved in the functioning of a blockchain, in order to provide interested operators with the basic architecture of such a '*technology of technologies*' which is nevertheless still '*much discussed but little understood*'[20].

Adopting the same multidisciplinary approach, it seems necessary to open the present work with an analysis of five essential features that characterise blockchain, with the aim of unpacking its key technological components. Indeed, the understanding of the following technical peculiarities is useful for carrying out the purely legal remarks that will be made below with specific reference to the logistics and transport sector.

For sake of clarity, I anticipate that a separate section of this paper will be devoted to the technical and legal regime of smart contracts, which is one of the most difficult but fascinating aspects of the technology at stake.

Finally, we shall bear in mind that blockchain is still a new technology, with rapidly evolving functionality. Thus, this section explores also the differences between the four generations of blockchain, that have already been discerned from literature[21].

D., *Blockchain and the law*, Baden-Baden, 2019; WALCH A., *The Bitcoin Blockchain as Financial Market Infrastructure: A Consideration of Operational Risk,* in *NYU Journal of Legislation and Public Policy*, 2015, 18 (4), p. 837.

[19] TECH LONDON ADVOCATES' (TLA) BLOCKCHAIN LEGAL AND REGULATORY GROUP, *Blockchain: legal and regulatory guidance*, 2020, available at https://www.lawsociety.org.uk/topics/research/blockchain-legal-and-regulatory-guidance-report

[20] DIMITROPOULOS G., *The Law of blockchain*, cit., p. 1127.

[21] SCHREPEL T., *Is Blockchain the death of antitrust law?* in *Geo. L. Tech. Rev.*, 2019, p. 281; CENTER FOR SUPPLY CHAIN RESEARCH (CSCR), *White paper on Blockchain – Fundamentals and Enterprise Applications [Part 1]*, November 2021, available at https://sites.psu.edu/cscrresearchportal/.

1.1. Blockchain technology in pills: five essential assumptions

A. Blockchain is a chain of blocks

As tautological as it may seem, such a statement is actually less trivial than it sounds.

Indeed, one of the cornerstones blockchain's 'data structure' is the fact that each block represents a transaction, while also forming part of the chain in the sense that the output of one transaction becomes the input for the next. Therefore, each block contains congregated, mathematically encrypted transaction records which may represent financial transactions, inventory records, food shipment records, parts certifications, sensor data, or any other types of assets that can be prescribed in a digital form.

In addition, each block contains metadata, such as time stamps and cryptographic fingerprints known as 'hash' functions; here, except for the 'genesis' block (*i.e.* the first block in the chain), it is the previous block's hash that links the blocks together, as the following figure clearly shows.

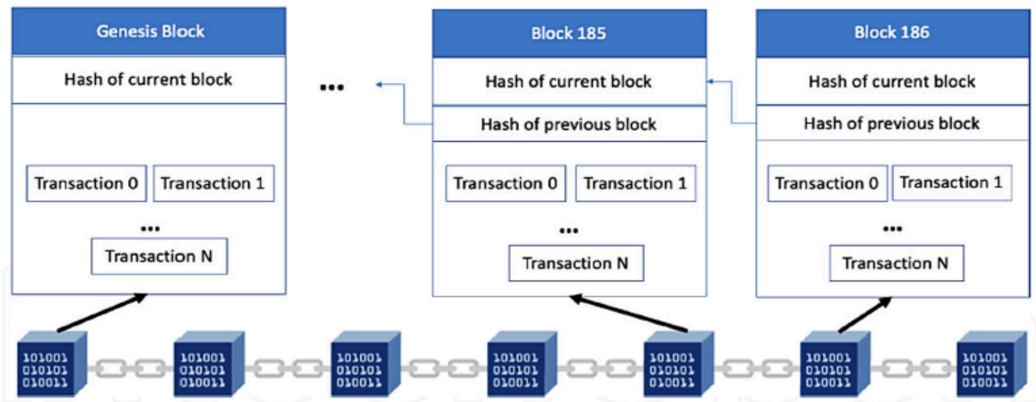

Figure 1. (Source: ZHANG J., *Deploying Blockchain Technology in the Supply Chain*, in THOMAS C., FRAGA-LAMAS P. AND FERNÁNDEZ-CARAMÉS T.M. (eds.), *Computer Security Threats,* 2019).

Hash functions underpin blockchain's information security, serving the dual purpose of identification and integrity verification. With a hash providing a unique digital fingerprint of the data, blocks in a blockchain can be identified by their hash and linked together in the chain so that a blockchain retains the complete history of transactions executed since the very first one[22].

This feature makes the chain extremely difficult to force by someone acting from the outside, as any attempt to modify one block would have immediate (or, anywaym real-time) and visible consequences on all the previous and following blocks[23]: because any change in any part of the data will result in a completely different hash, network participants can always verify that any block of data has not been tampered with by checking the hash of the data against the previously computed and stored hash value for that data[24].

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[22] SCHREPEL T., *Is Blockchain the death of antitrust law?*, cit.

[23] ANWAR H., *Consensus Algorithms: The Root of Blockchain Technology*, in *101 Blockchains*, August 25, 2018, available at https://101blockchains.com/consensus-algorithms-blockchain/; BOAVENTURA A., *Demystifying Blockchain and Consensus Mechanisms – Everything You Wanted to Know but Were Never Told*, in *Oracle blog*, April 12, 2018, available at https://blogs.oracle.com/integration/post/demystifying-blockchain-and-consensus-mechanisms-everything-you-wanted-to-know-but-were-never-told; BOTTONI P., GESSA N., MASSA G., PARESCHI R., SELIM H., ARCURI E., *Intelligent Smart Contracts for Innovative Supply Chain Management*, in *Frontiers in Blockchain*, 2020, 3; BRAKEVILLE S., PEREPA B., *Blockchain Basics: Glossary and Use Cases*, in *IBM tutorials*, August 21, 2017, available at https://developer.ibm.com/tutorials/cl-blockchain-basics-glossary-bluemix-trs/; GUPTA M., *Blockchain for Dummies*, New York, 2020; RICHTER A., *Blockchain for a Better Supply Chain*, in *Material Handling & Logistics*, April 2, 2019, available at https://www.mhlnews.com/technology-automation/article/22055549/blockchain-for-a-better-supply-chain; SABRY S., KAITTAN N., MAJEED I., *The Road to the Blockchain Technology: Concept and Types*, in *Periodicals of Engineering and Natural Sciences*, 2019, 7, p. 1821; SARMAH S., *Understanding Blockchain Technology*, in *Computer Science and Engineering*, 2018, 8, p. 23; THARAKA H., YLIANTTILA M., MADHUSANKA L., *Survey on Blockchain Based Smart Contracts: Applications, Opportunities and Challenges*, in *Journal of Network and Computer Applications*, 2021, 177; VOSHMGIR S., *What is Blockchain?*, in *Blockchain Hub*, July 2019, available at https://blockchainhub.net/blockchain-intro/; WORLD ECONOMIC FORUM, *Inclusive Deployment of Blockchain for Supply Chains: Part 3 – Public or Private Blockchains – Which One Is Right for You?*", White paper of July 2019.

[24] CHOW J., *Blockchain Underpinnings: Hashing*, in *Medium*, January 13, 2016, available at https://medium.com/@ConsenSys/blockchain-underpinnings-hashing-7f4746cbd66b; POSTON H., *Hash Functions in Blockchain*, in *Infosec Resources*, September 29, 2020, available at https://resources.infosecinstitute.com/topic/hash-functions-in-blockchain/.

Besides, blockchain technology is structured on asymmetric key algorithms involving two keys, namely public and private keys[25], that work in tandem for encryption, decryption, and digital signatures.

Here, the private key acts as a secret password, which parties do not need to share, whereas the public key serves as a reference point that could be freely communicated: the sending party can attach to a message a 'digital signature' generated by combining the message with its private key; once sent, the receiving party can firstly use the sending party's public key to check the authenticity and integrity of the message and secondly decrypt the message by using his private key[26].

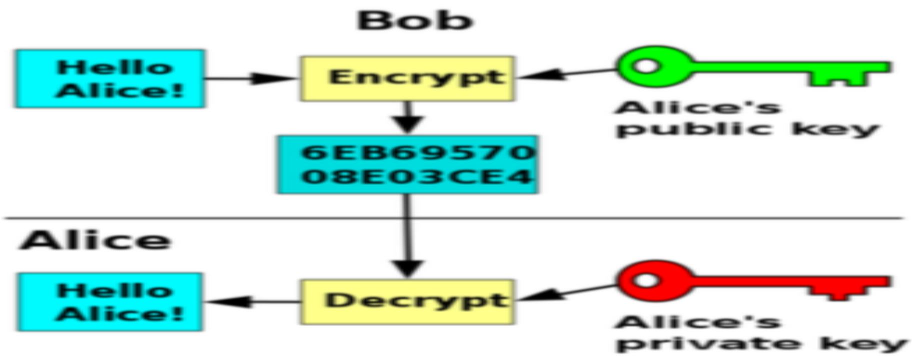

Figure 2.

In a blockchain, transactions occur between different addresses, where each sender can transmit encrypted information securely using public keys[27]. Then, private keys are required to decrypt the encrypted information, and only the intended recipients can do so with their own and unique key[28]. Overall,

[25] On this topic, see DIFFIE L., HELLMAN M., *New Directions in cryptography,* in *IEEE Transactions on Information Theory*, 1976, 22 (6), p. 644; RIVEST R.L., SHAMIR A., ADLEMAN L., *A Method for Obtaining Digital Signatures and Public-Key Cryptosystems*, in *Communications of the ACM*, 1978, 21 (2), p. 120.

[26] D'ANGELO D.M., MCNAIR B., WILKES J.E., *Security in Electronic Messaging System*, in *AT&T Technical Journal*, 1994, 73 (3), p. 7.

[27] BERKE A., *How Safe Are Blockchains? It Depends*, in *Harvard Business Review*, March 7, 2017, p. 2; CHOW J, *Blockchain Underpinnings*, cit.

[28] ANWAR H., *Consensus Algorithms*, cit.; GANNE E., *Can blockchain revolutionize international trade?*, Geneva, 2018.

asymmetric key cryptography enables transacting parties to interact privately over the Internet, authenticate their identity, and verify blockchain data[29], narrowing the ability of a blockchain-based account's holder to refuse the fact that a transaction occurred[30].

This is the reason why it has been stated that '*unlike Pinocchio, the blockchain does not lie*'[31].

B. Blockchain works as a distributed ledger between its participants

Blockchain ledger is not centralised but distributed among units (so-called 'nodes') belonging to a relevant peer-to-peer network (blockchain is, indeed, a specific DLT).

That being said, in a 'pure' ('permission-less') blockchain, the common database may be modified by each node, acting as a 'miner' (*i.e.* performing a specific cryptographical task), proving all the other nodes in the network share the solution and electronically consent to this, again through cryptographical *consensus* mechanisms (alternatively, the so-called 'proof of work' or 'proof of stake', see also *infra*). After such a computational process has been completed (and, thus, each new transaction is broadcasted and cryptographically validated by network participants using a determined *consensus* mechanism), all validated transactions are time-stamped and bundled in a new 'block', which becomes permanent part of the ledger[32].

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[29] THE MIT CENTER FOR TRANSPORTATION & LOGISTICS, *A Consensus on the Truth? Blockchain Applications in Supply Chain Management*, Summary Reports of the Roundtable events of October, 2017 and 2018, April 25.

[30] Unless a party can prove that the private key associated with the account was somehow compromised, see NARAYANAN A., BONNEAU J., FELTEN E., MILLER A., GOLDFEDER S., *Bitcoin and Cryptocurrency Technologies: a Comprehensive Introduction*, Princeton, 2016.

[31] TAPSCOTT D., TAPSCOTT A., *Blockchain Revolution: how the technology behind bitcoin is changing money, business, and the world*, London, p. 282.

[32] See above footnote n. 20

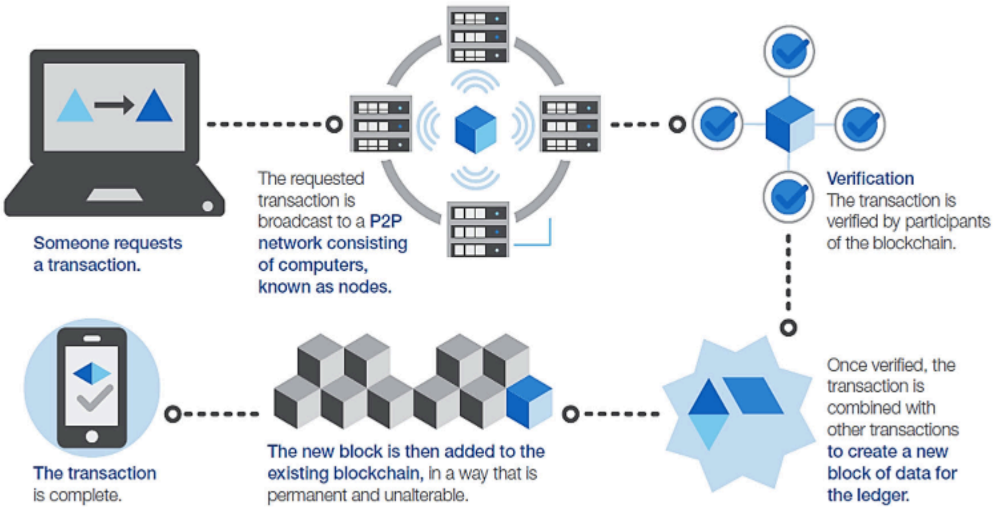

Figure 3. (Source: WORLD ECONOMIC FORUM, *Building Block(Chain)s for a Better Planet*, *Fourth Industrial Revolution for the Earth Series*, in collaboration with PwC and Stanford Woods Institute for the Environment, 2018).

The above aims to generate *trust* among all the nodes[33].

This is why blockchain enthusiasts assert that 'code' shall be considered as 'law': acting by means of shared and technologically monitored transactions, such a system would side-step the participants' need to rely on external 'authorities' or third parties expressly appointed to grant the integrity and truthfulness of the data exchanged (including, for example, notaries and lawyers)[34].

C. The ledger is decentralised and distributed across the network

In a blockchain, each participant owns not only a copy, but *the* original ledger of all the digitally signed transactions exchanged through the network. In other words, all the computers store an exact copy of the blockchain, and the

[33] In the words of Satoshi Nakamoto, blockchain is based on '*cryptographic proof instead of trust*', NAKAMOTO S., *Bitcoin*, cit.

[34] According to IANSITI M., LAKHANI K.R., *The Truth About Blockchain*, in *Harv. Bus. Rev.*, 2017, p. 118, "*with blockchain, we can imagine a world in which contracts are embedded in digital code and stored in transparent, shared databases, where they are protected from deletion, tampering, and revision. In this world every agreement, every process, every task, and every payment would have a digital record and signature that could be identified, validated, stored, and shared. Intermediaries like lawyers, brokers, and bankers might no longer be necessary. Individuals, organizations, machines, and algorithms would freely transact and interact with one another with little friction. This is the immense potential of blockchain*'.

underlying software protocol ensures that all such copies are consistently and simultaneously updated.

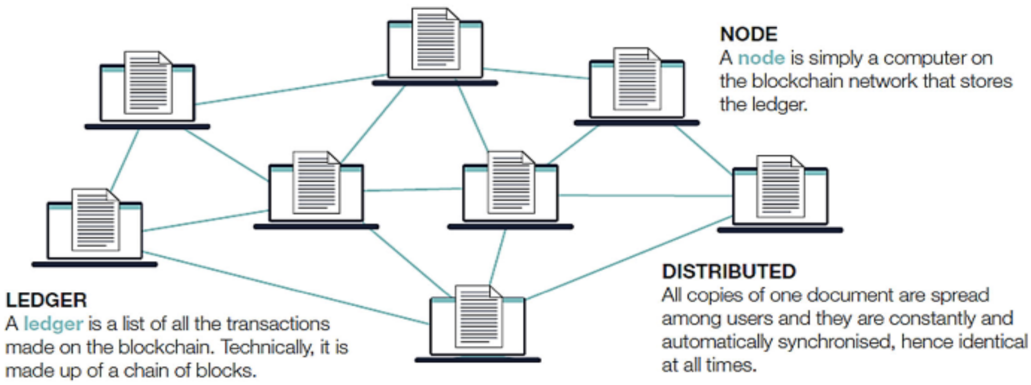

Figure 4. (Source: ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, *OECD Blockchain Primer*, available at https://www.oecd.org/finance/OECD-Blockchain-Primer.pdf).

Moreover, when using a blockchain, every user agrees to a set of procedures, called protocols, which basically governs it[35].

In other terms, no single party has the power to modify the transactions once they are stored on a blockchain, as a *consensus* mechanism would otherwise be required, in order to allow untrusted independent participants to reach an agreement on the order and correctness of the set of transactions that constitute a block.

Here, a wide variety of consensus mechanisms have been devised, each bringing different advantages and disadvantages based on various design concepts[36] (such as speed, energy, efficiency, scalability, tamper resistance etc.),

[35] DANNEN C., *Introducing Ethereum and Solidity: foundations of cryptocurrency and blockchain programming for beginners*, Apress, 2017, where the author states '*[A] protocol is a system of rules that describes how a computer (and its programmer) can connect to, participate in, and transmit information over a system or network. These instructions define code syntax and semantics that the system expects. Protocols can involve hardware, software, and plain-language instructions*'.

[36] GANNE E., *Can blockchain revolutionize international trade?*, cit.; JALAL I., SHUKUR Z., BAKAR A., *Study on Public Blockchain Consensus Algorithms: A Systematic Literature Review*, in *Preprints*, November 12, 2020.

the most widely used being the above mentioned 'proof of work'[37] or 'proof of stake'[38].

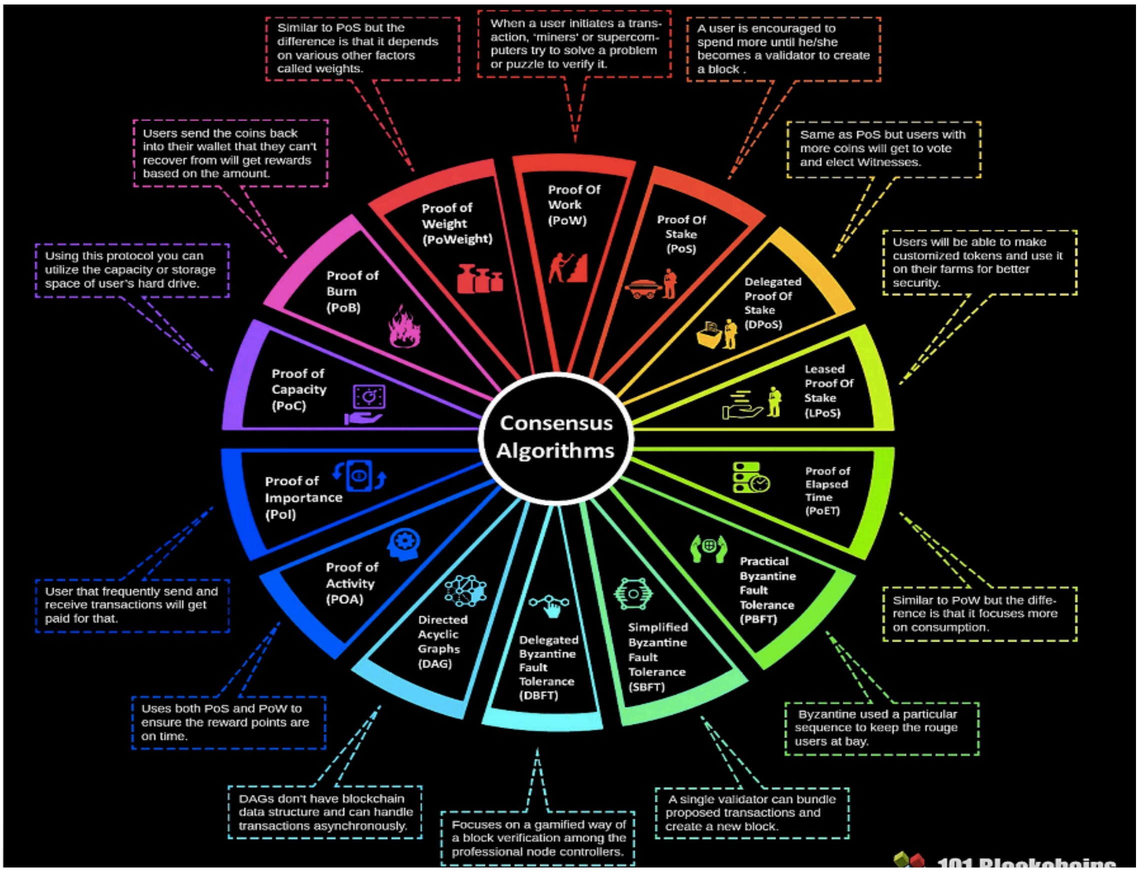

Figure 5. (Source: ANWAR H., *Consensus Algorithms: The Root of Blockchain Technology*, in *101 Blockchains*, August 25, 2018, available at https://101blockchains.com/consensus-algorithms-blockchain/).

[37] As defined by CSCR's report of 2021 (see above), PoW *consensus* mechanism is '*the first blockchain algorithm introduced in the blockchain network and is used in Bitcoin blockchain. The individual nodes called miners perform a PoW process called mining, which involves solving complicated mathematical puzzles. The puzzles can only be solved with trial and error. Hence, miners require extensive computational power for finding solutions quickly. After solving mathematical puzzles, miners receive bitcoins and a small transaction fee, as well as a block as a reward if they are the first one to find the solution. The main flaws of the PoW are intensive computing resource and energy consumption, centralization of miners/mining power, and the 51 percent attack*'.

[38] CSCR's report of 2021 defines PoS *consensus* mechanism as follows: '*In PoS, the network selects an individual node who would act as a validator based on their proportional stake in the network. Thus, instead of investing in expensive computer equipment in a race to mine blocks as in the case of PoW, a validator invests in the coins of the system. Compared to PoW, PoS consensus algorithm is much more efficient and less vulnerable to the threat of a 51 percent attack. However, since only a handful of nodes get to participate in the staking on the network, individuals with the most coins could eventually control most of the system*'.

These feature makes a blockchain electronic ledger potentially *tamper-proof* and almost[39] *immutable*, in the sense that any transaction generated within is generally irreversible.

D. Blockchain users are identified by pseudonymous

Besides, blockchains are characterised by pseudonymity.

By relying on digital signatures and public-private key cryptography, blockchains allow each node to store information without revealing his/her true identity[40] nor undermining his/her role of 'trusted party' due to community reliance in the system itself.

Indeed, one of the core ideas behind blockchain is that parties can interact with one another even if they do not know each other, provided that they trust the underlying technical infrastructure and the rules embedded in a blockchain's protocol[41].

E. In blockchain digital world goods and values are converted in tokens

Tokenization is the process of converting anything of 'value' into a digital representation or a 'token'[42].

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[39] For sake of accuracy, and especially in PoW blockchain, it is preferable to refer to temper-proof transactions rather than immutable, because blockchains are susceptible of the so-called "51% attack". See FINCK M., *Blockchain Regulation and Governance in Europe*, Cambridge, 2018, p. 30.

[40] DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 38-39.

[41] *Ibid.*

[42] VIGNA P., CASEY M., *The truth machine: the Blockchain and the future of everything*, New York, 2018, p. 99 ('*How do tokens work? Just as Bitcoin's protocol steers users and participants into certain actions that serve the community's interest—in its case, creating a secure, reliable ledger that all can trust—the programs that run tokens incorporate incentives and constraints that encourage certain pro-social behavior. A new concept—token economics—is emerging. It encapsulates the idea that we can embed into these "programmable" forms of money a way to steer communities toward desired common outcomes. Tokens might help us solve the Tragedy of the Commons. In other words, they could be a big deal*').

Transactions and other interactions in a token-based blockchain involve the secure exchange of value that comes in the form of these digital tokens: while blockchain – as illustrated above – provides the technological means to facilitate the exchange/ownership of data and, at the same time, to spread trust in the network, the tokenization is indeed essential to digitally represent the goods and values to be exchanged therein[43].

In the practice, two types of tokens on blockchains have been developed: indeed, tokens can be native to the blockchain (so called '*native tokens*' or '*crypto assets*') or digital representations of off-chain physical goods and assets (so-called '*tokenized asset*').

These two types of tokens can be further distinguished by their 'fungibility':

a) native tokens are 'fungible' tokens that possess the same features as a real-world currency and are normally minted based on the possession or proof of possession of an asset[44]. Then, they can be assigned, transferred, redeemed, used as payment, or taken on or off circulation, depending on their use cases[45];

b) tokenized assets are 'non-fungible' tokens ('NFTs'), capable of extending blockchain applications far beyond financial services. Indeed, they allow the creation of 'digital twins' of physical assets in a blockchain network, whose economic value is conferred to the NFT and represented by the ownership of the NFT on the blockchain. As it will be further discussed in the following paragraphs, the use of such

[43] ARUN J., CUOMO S., GAUR N., *Blockchain Technology*, in *Inform IT*, March 25, 2020, available at https://www.informit.com/articles/article.aspx?p=2955143; WORLD ECONOMIC FORUM, *Inclusive Deployment of Blockchain for Supply Chains: Part 3*, cit.
[44] ARUN J., CUOMO S., GAUR N., *Blockchain Technology*, cit.; IREDALE G., *The Difference Between Fungible and Non-Fungible Tokens*, in *101 Blockchains*, March 24, 2021, available at https://101blockchains.com/fungible-vs-non-fungible-tokens/.
[45] For example, ERC ('*Ethereum Request for Comment*' is a well-known fungible token standard, defined by Ethereum. See redale 2021; Subbaraman and Krishnan 2021.

a second type of tokens[46] may be relevant for the purposes of the supply chain management: by way of examples, it would be possible to use NFTs to (i) track and exchange supply chain documentation, (ii) conduct trades and (iii) manage movements of goods, thanks also to a widespread use of smart contracts[47].

For sake of clarity, the following table resumes the main differences between such 'families' of tokens:

Fungible Tokens	Non-Fungible Tokens
Identical Tokens of the same type are identical to another of the same type. They have identical specifications.	**Unique** Each token is unique and differs from another token of the same type. They have unique information and attributes.
Interchangeable A token can be interchanged for another with the same value. A 20 EUR bill can be replaced with a combination of other bills and coins that amount to the same value.	**Non-interchangeable** NFTs cannot be replaced with tokens of the same type as they represent unique values or access rights.
Divisible Fungible assets are divisible into smaller amounts. It is irrelevant which and how many units you use, as long as it adds up to the same value.	**Non-divisible** Tokens that are tied to one's identity, like certificates and degrees, are not divisible. It does not make sense to have a fraction of a degree, and they are not interchangeable either.

Table 1. (Source: VOSHMGIR S., *What is a fungible token? What is a non-fungible token?*, in *Blockchain Hub*, July 2019, vailable at https://blockchainhub.net/blog/blog/nfts-fungible-tokens-vs-non-fungible-tokens/).

1.2. From permissionless to permissioned blockchain

The previous paragraphs are focused on main features of a 'pure' blockchain model, which is open and accessible to each participant, and then '*permissionless*'

[46] Currently, the most pupular standard in which NFTs are created is ERC-721 running on Ethereum. It has been written that these tokens have the advantage to be compatible with other blockchain networks, such as EOS and NEO, allowing them to be transacted thereby (see IREDALE G., *The Difference Between Fungible and Non-Fungible Tokens*, cit.).

[47] ARUN J. CUOMO S., GAUR N., *Blockchain Technology*, cit.; IREDALE G., *The Difference Between Fungible and Non-Fungible Tokens*, cit.; TASCA P., TESSONE C., *A Taxonomy of Blockchain Technologies: Principles of Identification and Classification*, in *Ledger*, 2019, 4, p. 1; WORLD ECONOMIC FORUM, *Inclusive Deployment of Blockchain for Supply Chains: Part 3*, cit.

(among this type of blockchains there are indeed the most famous ones, such as Bitcoin and Ethereum).

In the scenario described above anyone can read and can propose new transactions, because there is potentially no guarding on the actors and no access control, thanks in part to the original influence of the open source and '*cypherpunk movements*'[48]. Despite some limitations can be provided in the chain (perhaps only allowing users to send tokens among them), transactions in permissionless blockchain are generally secured by merely requiring new entries to include a proof of work[49].

However, alongside permissionless blockchain, a number of alternative private blockchains are gradually emerging, also called '*permissioned*'.

Despite relying on a similar peer-to-peer network, this second type of DLT can be controlled by interested parties, who may decide who is or is not allowed to join the network. More specifically, a central authority or consortium selects which parties may enter the network, thereby imposing limitations even on who is allowed to record information on the shared database[50]. By way of example, in a permissioned blockchain, the creator can restrict reading permissions to certain participants, or limit the completion of new transactions to a predetermined one.

Furthermore, private blockchains can be subdivided into three different categories:

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[48] SCHREPEL T., *Is Blockchain the death of antitrust law?*, cit., p. 290; HUGHES A., *A Cypherpunk's Manifesto*, in *ACTIVISM*, 1993, available at https://www.activism.net/cypherpunk; GOLDSMITH A., WU T., *Who controls the internet? Illusions of a borderless world*, Oxford, 2006.

[49] See above and, furthermore, ROSIC A., P*roof of Work vs Proof of Stake: Basic Mining Guide*, in *Blockgeeks*, 2017, available at https://blockgeeks.com/guides/proof-of-work-vs-proof-of-stake/.

[50] BERKE A., *How safe are Blockchains? It depends*, in *Harvard Business Review*, March 7, 2017; DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 31 ss.

a) ‘*single entity blockchains*’: as their name suggests, in these cases a single entity will set up the protocol and run the blockchain, while reading permission may be public or restricted to certain participants. In this case, a blockchain can also be a hybrid ‘*semi-private*’ one, when it is run by a single company that grants access to any qualified user;

b) ‘*consortium blockchain*’: regardless of the technical particulars, this type of private blockchain operates under the leadership of a group instead of a single entity, the consensus process being controlled by a pre-selected set of nodes (e.g. it could be made of five companies, each of which operates a node, and three would have to sign in order to validate a block).

The main differences between public, private and semi-private blockchain are summarised in the following table:

Blockchain types	Public blockchain	Semi-Private blockchain	Private (single entity) blockchain	Private (consortium) blockchain
Access	No permission required	Qualified users via online approvals	Members only	Members only, who could be co-founders
Typical implementation	As a public blockchain application	One company launches and acquires users after	Via a private blockchain implementation	Via a private blockchain implementation
Innovation target	New business models	Supporting existing models or launching new services	Supporting existing models or launching new services	Processes within existing relationships
Blockchain governance	Public consensus	Controlled by a single owner	Controlled by a single owner	Equal weight to all participants
Number of users	Millions (billions?)	Hundreds of thousands	Dozens to few thousands	Dozens to few thousands

Table 2. (Source: SCHREPEL T., *Is Blockchain the death of antitrust law?*, cit., p. 292).

With the rise of permissioned blockchains, some authors have immediately stated that they cannot be conceptually configured as real blockchains [51].

Indeed, permissioned ledgers seems to bring along an abrupt awaking from the utopic dream of a fully decentralized system governed by protocols and other code-based rules that are automatically executed by the network itself, potentially without the need for intermediaries.

Otherwise, the above must not be approached as a 'failure' of blockchain technology but, rather, as step forward in its attempt to spread from the non-beaten path of cryptocurrencies into a potential wide diffusion in our everyday life.

In this vein, the technology at stake place itself in a dynamic context, where four generations of blockchain can already be discerned from literature[52], as it will be described in the following paragraph.

1.3. Blockchain generations: an overview

In order to correctly understand the considerations that will be made about the possible legal implementation of blockchain technology in the logistics and transport sector, another important feature of the technology must be pointed out.

As mentioned above, blockchain and its development should be seen in a dynamic and evolutionary perspective, in which four different generations of blockchain have been already identified[53].

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[51] KONASHEVYCH O., *Why 'permissioned' and 'private' are not blockchains*, in *Ledger Journal*, 2019; WUST K., GERVAIS A., *Do you need a Blckchain?*, in *Cypto Valley Conf. on Blockchain Tech*, 2018, p. 45.

[52] CARSON B., ROMANELLI G., WALSH P., ZHUMAEV A., *Blockchain beyond the Hype: What is the Strategic Business Value?*, in *McKinsey Insights*, June 19, 2018.

[53] CENTER FOR SUPPLY CHAIN RESEARCH (CSCR), *White paper on Blockchain*, cit., p. 7.

Each one of these steps of blockchain evolution will be briefly presented below, together with its most representative innovation adopted in the path towards a massive application of this technology in industries, accordingly with the following figure:

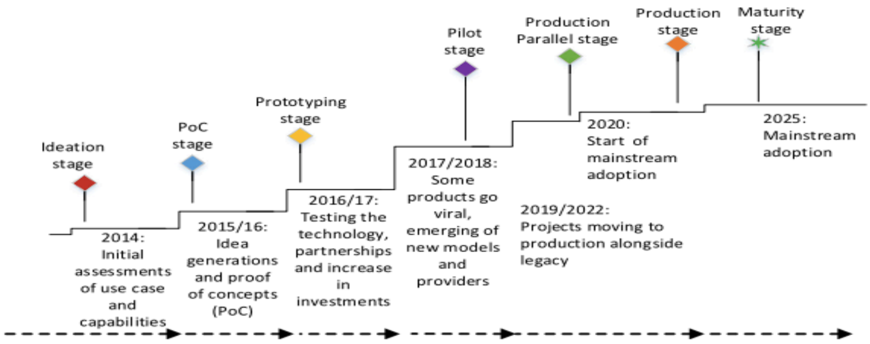

Figure 6. (Source: SANKA A.I., IRFAN, M., HUANG I., CHEUNG R., *A Survey of Breakthrough in Blockchain Technology: Adoptions, Applications, Challenges and Future Research*, in *Computer Communications*, 2021, 169, p. 179).

A. Blockchain 1.0 (2009): the age of cryptocurrencies

As anticipated, blockchain technology is born to ensure correct and distributed monetary transactions through the exchange of cryptocurrencies that could operate without the need for a centralized middleman.

This first generation of blockchains raised when an unidentified individual (or group of individuals) under the alias of Satoshi Nakamoto published the notorious white paper '*Bitcoin: A Peer-to-Peer Electronic Cash System*' of October 31, 2008. The first ever Bitcoin transaction took place on January 12, 2009, when *Nakamoto* sent 10 Bitcoins to a computer scientist Hal Finney, and since its launch Bitcoin has become one of the largest payment systems in the world, working as a pure permissionless blockchain grounded on a proof of work consensus mechanism[54].

[54] Aside from Bitcoin, other examples of blockchain platforms in this generation are Litecoin, Dogecoin, Reddcoin.

The protocols underlying Bitcoin did not come out of the blue: instead, they were the unique combination of old technologies already developed (P2P, cryptography etc.) to build decentralized networks sharing and transferring not just bits corresponding to information (as the Internet does), but real assets.

However, the more people considered Bitcoin, the more its limits became apparent: Bitcoin, indeed, excelled as a platform to facilitate the exchange of digital currency, but without updating the underlying protocol, it could not be used for much more. Besides, Bitcoin's decentralized structure made its protocols hard to update and improve, and the network lacked formal governance, relying on the efforts of a small group of developers who slowly revise and fix bugs in the underlying software[55].

Then, new blockchain-based projects were launched with the aim of addressing these limitations and sought to leverage the power of this technology not just to store information related to the transfer of a digital currency but to build a medium to host decentralized applications that rely on blockchains, at least partially, for their underlying functionality.

B. Blockchain 2.0 (2015): the implementation of smart contracts and asset tokenization

Therefore, the second generation of blockchain distinguishes itself from the predecessor by its expanding functionalities beyond cryptocurrencies.

Led by the automation and the development of trusted code platforms like Ethereum, Blockchain 2.0 introduced the concept of '*smart contracts*' and made possible the '*digital tokenization of physical assets*'. Together, these technologies supported decentralized autonomous organizations (DAOs), where '*decentralized*' refers to the absence of any central body interventions, and

[55] DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 27.

'*autonomous*' refers to the amplification of smart contracts and encoded transactions on the blockchain.

In this phase of its maturity, blockchain technology has increasingly been used as a layer supporting so-called smart contracts, *i.e.* '*a set of promises, including protocols within which the parties perform other promises. The protocols are usually implemented with programs on a computer network, or in other forms of digital electronics, thus these contracts are 'smarter' than the paper-based ancestors. No use of artificial intelligence is implied*'[56].

The next chapter will be entirely dedicated to a closer study of smart contracts and their legal regime, if any. For sake of clarity, we can as of now describe, in a nutshell, smart contracts as self-executing protocols, whereby some the terms of an agreement between two parties are written directly into code, which activates itself when certain conditions occur in an '*if … then*' computational logic.

The first blockchain to enable the creation and deployment of sophisticated smart contracts was the Ethereum blockchain. Built on the efforts of Bitcoin, Ethereum added richer functionality to enable parties to deploy smart contracts on a blockchain just as one would deploy code for a website on a server[57]. Moreover, Ethereum has been mainly developed for the applications which require tokenization and the transfer of tokens through smart contracts[58].

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[56] SZABO N., *Smart Contracts: Building Blocks for Digital Markets*, reprinted in http://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart_contracts_2.html. See also CONG L.W., HE Z., *Blockchain Disruption and Smart Contracts*, in *The Review of Financial Studies*, 2019, 32 (5), p. 1754.

[57] BUTERIN V., *Ethereum White Paper*, 2013, available at https://github.com/ethereum/wiki/wiki/White-Paper.

[58] BOTTONI P., GESSA N., MASSA G., PARESCHI R., SELIM H., ARCURI E., *Intelligent Smart Contracts*, cit.; CUMMINGS S., *The Four Blockchain Generations*, in *Medium*, 2019, available at https://medium.com/the-capital/the-four-blockchains-generations-5627ef666f3b.

Given the underlying design of the network, however, running code via Ethereum is slow and potentially expensive and this hindered its diffusion in structured business.

C. Blockchain 3.0 (2018): the enterprise adoption

In 2019, enterprise blockchain adoption was finally proclaimed[59], with the aim of addressing the major limitations of the previous 'generations'.

A first line of research has enabled the development of the distributed application ('dApp') capabilities of blockchain: dApps run on top of blockchain infrastructure, typically using smart contracts[60].

Simultaneously, inter-blockchain processes (or 'BC2BC') have been implemented to enable industries' ability to process transactions between different blockchains and to improve expansion capability of the system. Cross-chain communication techniques and technologies such as sidechain and sub-blockchain may represent important advancement in this area, allowing different transactions to perform independently on multiple chains, and can occur in one-way (from one sidechain to another) or two-way (both sides of two sidechains) manners.

Significant benefits of these technologies are that they provide some interoperability between blockchains, in a way that any changes made in the data in one blockchain can be immediately updated in another; therefore, an actor of one blockchain can access resources from another blockchain without deliberately joining it. This is the reason why blockchain 3.0 has been

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[59] SANKA A.I., IRFAN, M., HUANG I., CHEUNG R., *A Survey of Breakthrough in Blockchain Technology: Adoptions, Applications, Challenges and Future Research*, in *Computer Communications*, 2021, 169, p. 179.

[60] HEINTZMAN D., *A Brave New World: Fourth Generation Blockchain*, in *Burnie Group Insights*, March 13, 2019, available at https://burniegroup.com/a-brave-new-world-fourth-generation-blockchain/.

considered as capable to eliminate network bottlenecks, and improve the overall throughput, availability, and scalability of the system[61].

In the sector of logistics and transportation, the core example of such a stage of blockchain technology is *TradeLens*, APM-Maersk's project developed with IBM from 2017, which will be discussed in more detail below.

D. Blockchain 4.0 (2021): the convergence with AI and IoT

The step forward, *i.e.* blockchain 4.0, is still largely in a hypothetical state.

Indeed, a growing consensus can be gauged on the fact that the next-gen blockchain would materialize after a conversion of blockchain 3.0 and artificial intelligence ('AI') and Internet of Thing ('IoT').

In this sense, expectations are high and envisage a system where fully AI-based consensus algorithms will replace the presence of humans from certain roles in the blockchain, such as validating transactions and adding the new blocks in the ledger. This sort of new consensus algorithm would also help to save time and overconsumption of energy as, otherwise, Bitcoin and Ethereum still require. Moreover, once the instructions are offered to AI, it could not be biased to exhibit unequal behaviours to the engaged users to the blockchain for getting the various services; therefore, fair operations could be gained from this sort of blockchain and the blockchain would be more trusted to go for the mass adoption trend[62].

[61] XIA Y., GROVER A.S., LIEB R.C., *Keeping PACE with Blockchain in Ocean Transportation*, in *Supply Chain Management Review*, 2021, 3, p. 32.

[62] On this point, see *Fifth Generation of Blockchain Technology*, in *Hacker Noon*, February 24, 2021, available at https://hackernoon.com/fifth-generation-of-blockchain-technology-tg2933ez.

1.4. The rise of *lex cryptographica*

Having examined the main features of blockchain technology and its evolution, it is now time to address one of the most interesting legal issues that has been developed by scholars who are dealing with blockchain technology. Reference is made to the concept of *lex cryptographica* as the law governing the world of blockchain, which would not require 'external' regulations whatsoever[63].

Indeed, blockchain enthusiasts have already asserted that blockchain-based protocols and services operating autonomously hold out the potential to create tensions with existing laws and regulations, because these features have ann alleged capacity to implement an autonomous set of rules (the *lex cryptographica*) to be implemented by the underlying protocol and smart contracts running on a blockchain-based network.

According to this view, by relying on decentralized peer-to-peer networks, blockchain-based systems may be designed to operate autonomously and potentially independently of the whims of centralised intermediaries by implementing code-based rules that are more persistent and often harder to change than those deployed by traditional centralised operators[64]. Thus, individuals may decide whether to interact with these autonomous systems, frustrating legal regimes '*focused on implementing rules on central parties that currently control or help facilitate online activities*'[65], with the final aim of requiring '*the development of alternative mechanisms of regulation that better account for the distinctive characteristics of* lex cryptographica'[66].

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[63] DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 50; DE FILIPPI P., WRIGHT A., *Decentralized blockchain technology and the rise of* lex cryptographia, 2015, available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2580664.

[64] ABRAMOWICZ M., *Criptocurrency based law*, in *Arizona Law Review*, 2016, 58, pp. 359-420.

[65] DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 52.

[66] *Ibid.*

I will return to this theory to attempt an evaluation thereof in the context of the already-mentioned logistics and shipping industry, which is still considered to be one of the most promising areas for the application of blockchain technology.

Nevertheless, and more generally, it is possible to anticipate that, although fascinating and evocative, such a 'dogma' is probably too emphatic.

Indeed, it is undoubtedly true that the nature of blockchain technology can make regulation through its code very powerful. Likewise, it is also true that the 'tamper-proof' nature of the ledger, as well as its potentials for automating transactions, makes *lex cryptographica* a potentially efficient regulatory code[67].

Nevertheless, *lex cryptographica* (as well as blockchain technology) it is not intended to live in a *vacuum* but, sooner or later, it shall face the external regulation coming from the ordinary law of the 'real' world. Then, on-chain rules might eventually produce legal effects if they are recognized by a national legal order when the blockchain has an off-chain interface connecting into the off-chain world[68].

In other words, '*by the time a blockchain based organisation "exits" the on-chain world, it loses its alleged autonomy and must abide by the off-chain rules*'[69].

A more realistic approach to the *lex cryptographica* seems therefore advisable, and it requires stakeholders, policymakers and legal practitioners to consider the complementarity, rather than the subsidiarity, between the '*rule of code*' and the '*rule of law*'[70].

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[67] DIMITROPOULOS G., *The Law of blockchain*, cit, p. 1143.

[68] '*A smart contract becomes a smart legal contract if, in case of a breach, the damaged party pursues damages or enforcement before a national court and which finds that the contract has the form and the content of a traditional contract*', see CAPPIELLO B., *Blockchain Based Organisations and the Governance of In-Chain and Off-Chain Rules: Towards Autonomous (Legal) Orders?*, in CAPPIELLO B., CARULLO G. (eds.), *Blockchain*, *Law and Governance*, Berlin, 2020, p. 1

[69] *Ibid.*

[70] FINCK M., *Blockchain Regulation*, cit.

Indeed, while blockchains are perceived (in a way, reasonably) as self-enforcing mechanisms, they are in fact not, since they necessarily have to deal with the real world, its laws, its rules and its actors[71]. Hence, the need of development of a legal and economic framework arises for the future shaping of blockchain and its spreading in various sectors of industry.

This is the reason why it is important to understand *now* the fundamentals of such a new technology and the opportunities it can provide, in order to create a real interplay between the physical world and *lex cryptographica*, which would allow the technology to enter in its maturity stage and to exploit all its potentials[72], in in a way similar to what has been doing with the internet[73]. Here, the real challenges for the law lie in the details and in the nuances[74], such as (i) how do legal terms have to be conceptualised (and changed) in order to cope with digitalization; (ii) to what extent are smart contracts consistent with contract law; (iii) to what extent may technology be used to enforce the law, and vice-versa.

Otherwise, and as qualified research report on this point[75], the hype surrounding blockchain is destined to progressively die out and such an innovative technology may hang in the balance between unrealistic expectations

[71] YEUNG K., *Regulation by Blockchain: the emerging battle for supremacy between the Code of Law and Code*', in *Modern Law Review*, 2019, 82, p. 207.

[72] '*As the political economy of the law of blockchain will become more intricate and multi-layered, it is important to already lay the right foundations during the first steps of its development*', see DIMITROPOULOS G., *The Law of blockchain*, cit., p. 1192.

[73] See generally GOLDSMITH J., WU T., W*ho controls the Internet?*, cit.; TSAGOURIAS N., *The Legal Status of Cyberspace*, in *Research Handbook on International Law and Cyberspace*, 2015, 13, p. 17.

[74] OSTER J., *Code is code and law is law – the law of digitalization and the digitalization of law*, in *International Journal of Law and Information Technology*, 2021, p. 1.

[75] *Hype Cycle for Emerging Technologies*, 2021, available at https://www.gartner.com/en/newsroom/press-releases/2021-08-23-gartner-identifies-key-emerging-technologies-spurring-innovation-through-trust-growth-and-change.

and its place as an innovation whose solutions are still marked by random difficulties.

The need for regulation is, after all, one of the principal challenges to be faced by blockchain technology in the immediate future.

For sake of completeness, it is opportune to provide a brief overview of all such challenges in the following and final paragraph of this introductive section.

1.5. Challenges yet to be faced by blockchain technology for its widespread diffusion

A. Technical challenges

Among the technical challenges that blockchain is expected to face, scalability issues are among the most recurrent in literature. They mainly refer to the technology's low throughput (transactions per second) [76] and large storage data (e.g., more than 299 GB for Bitcoin), which discourages running full nodes by IoT devices since they cannot store all the blockchain data due to their small memory. The huge size of the blockchain data also affects the read performance of blockchain data requests[77].

In other words, existing blockchains are not as powerful and fast as other data management and therefore the speed and trust worthiness of these networks will likewise need to grow for private and public entities to leverage

[76] '*The low throughput of blockchain is caused by the long block interval and the small block size. There is a tradeoff between the block interval and the block size for getting the optimal throughput … Blockchain applications lag much behind their non-blockchain counterparts in terms of throughput. For example, Bitcoin and Ethereum handle 3–4 and 20 tps respectively. In comparison, Visa and PayPal handle 24,000 and 193 transactions respectively*', see SANKA A.I., IRFAN, M., HUANG I., CHEUNG R., *A Survey of Breakthrough in Blockchain Technology*, cit., p. 195.

[77] '*Blockchain servers such as Blockcypher perform less when compared to non-blockchain servers like Google. For example, Blockcypher supports 3 requests per second while Google on the other hand support 85,830 searches per second*' (*Ibid.*).

the technology for the development of novel applications and innovative business models.

Nevertheless, solving scalability issues is not a simple task.

Since blockchains are 'append-only' databases, each new transaction on the network causes the blockchain to grow; then, the larger a blockchain gets, the greater its requirements are in terms of storage, bandwidth, and computational power[78]. Here, there are already a few proposals on how to make blockchains scalable, but they have yet to be implemented in earnest[79].

Besides, security threats and vulnerabilities have been found in blockchain applications (mostly cryptocurrencies) despite the features of the technology. Scams, malware attacks, denial of service, sybil attacks, and network vulnerabilities are the commonly reported security issues. Loss of private keys due to the attacks, accidents, or recklessness also causes huge security breaches[80].

Finally, even though blockchain is pseudonymous, the physical identity of a user could be revealed over critical analysis of the transactions from a particular node or by the analysis of the network activities and the blockchain data[81].

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[78] See LUBIN K.J., *Blockchain Scalability*, O'Reily Media, January 21, 2015, available at: https://www.oreily.com/ideas/blockchain-scalability.

[79] "*For example, by moving certain transactions off a blockchain, developing faster consensus protocols, or dividing the shared database in ways that would enable a network to process transactions in parallel*", see DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 57.

[80] Cryptocurrencies worth $2 billion have been stolen mostly from exchanges since 2017, according to ORCUTT M., *Once hailed as unhackable, blockchains are now getting hacked*, 2019, available at: https://www.technologyreview.com/s/612974/once-hailed-as-unhackable-blockchains-are-now-getting-hacked/.

[81] BIRYUKOV A., KHOVRATOVICH D., PUSTOGAROV I., *Deanonymisation of clients in bitcoin p2p network*, in *Proceedings of the 2014 ACM SIGSAC Conference on Computer and Communications Security*, CCS '14, Association for Computing Machinery, New York, 2014, pp. 15–29.

Alternatively, the user's IP addresses could be extracted and linked with the user's wallet, breaking its privacy[82].

This constitutes a third strand of technical issues directly involving privacy matters.

B. Regulatory issues

As anticipated, the current lack or inadequacy of regulation is one of the greatest issues that impede blockchain adoptions worldwide. By way of example, according to a PWC's survey of 2018, 48% of respondents chose regulatory issues as the major setback for blockchain adoption[83].

Moreover, not only lack of regulation, but regulation itself constitutes a real challenge for blockchain's implementation. Indeed, as it has been pointed out by scholars, '*Regulating too soon could provide valuable guidance as to the legitimate uses of blockchain technology but could also stamp out potential benefits. Regulating too late may dissuade the most risk-adverse actors from exploring blockchains because of legal uncertainty while simultaneously allowing socially objectionable aspects of the technology to emerge*'[84].

C. Lack of understanding of blockchain

It has been pointed out that another major setback for blockchain adoption is the lack of understanding of the technology itself[85]: EY's 2018 survey of 576 Asia-pacific (excluding China) companies revealed that 68% of the companies

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[82] HARLEV M.A., SUN YIN H., LANGENHELDT K.C., MUKKAMALA R., VATRAPU R., *Breaking bad: De-anonymising entity types on the bitcoin blockchain using supervised machine learning*, in *Proceedings of the 51st Hawaii International Conference on System Sciences*, 2018.

[83] *PwC global blockchain survey 2018 - blockchain is here. What's your next move?*, 2018, available at: www.pwccn.com/global-blockchain-survey-2018.

[84] DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 57; on this point, see also WU T., *Agency Threats*, in *Duke Law Journal*, 2011, 60, p. 1841.

[85] SANKA A.I., IRFAN, M., HUANG I., CHEUNG R., *A Survey of Breakthrough in Blockchain Technology*, cit., p. 196.

do not trust blockchain because they lack understanding of the technology[86]. According to the Deloitte's 2019 survey of 1386 executives, 28% of the executives counted such an issue as one of the major barriers for its greater adoption[87].

This has probably a lot to do with the dominance of 'technical' staff in the blockchain area and their overly technological approach, which managers usually find hard to understand. A good example of this issue can be provided by the logistics sector, as it will be illustrated in greater detail below.

In many cases, supply chains are already moving billions of transactions and data, often in real time, through central databases with good data management, combined with supply-chain visualization and analytical prowess, can be achieved at scale today.

These solutions do not carry the additional burden of some of the technical complexities that blockchain can raise, as described above. Thus, the common view of the sector at stake may be that, when all parties in extended supply chains are known and trusted, a blockchain solution is probably not needed, as these known and trusted parties can be relied upon to provide a single, real-time version of the truth[88].

In such a situation, it seems easier to argue that centralized solutions like a cloud-portal would suffice to meet the needs of the stakeholders involved.

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[86] HUILLET M., *EY: Blockchain not understood by almost 70% of firms in Asia-Pacific*, 2019, available at https://cointelegraph.com/news/ey-blockchain-not-understood-by-almost-70-of-firms-in-asia-pacific.

[87] PAWCZUK L., MASSEY R., HOLDOWSKY J., *Deloitte 2019 global blockchain survey - Blockchain gets down to business*, 2019, in *Deloitte insights*, available at https://www2.deloitte.com/content/dam/Deloitte/se/Documents/risk/DI_2019-global-blockchain-survey.pdf.

[88] See the article *Blockchain technology for supply chains - A must or a maybe?*, in *McKinsey Insights*, September 12, 2017, available at https://www.mckinsey.com/business-functions/operations/our-insights/blockchain-technology-for-supply-chainsa-must-or-a-maybe.

D. Industry's reluctance to change current systems

According to the surveys mentioned above, blockchain still suffers from a reluctance phenomenon. Indeed, many companies are reluctant to replace or modify their existing systems with blockchain[89].

At the same time, it has been noted that organizations and industries are developing their own blockchains and applications to run on top of them, adhering to different standards. This defeats the purpose of distributed ledgers and fails to harness network effects.

In this context, a possible solution could be the creation of *consortium* of companies cooperating for the development of the blockchain infrastructure and implementing the applications that can be used by the participants to develop their own range of services[90].

One example of blockchain *consortium* can be found in the maritime industry and it is the Global Shipping Business Network ('GBSN'), which includes some of the largest companies involved in maritime transport such as CMA CGM, COSCO, Hapag-Lloyd and OOCL[91].

I will come back to this topic in the sections of this thesis that are specifically devoted to the possible deployment of blockchain technology in the logistics and shipping industry.

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[89] Out of the 1386 executives surveyed by Deloitte, 30% opined that reluctance to replace the existing system is the greatest barrier to blockchain adoption.

[90] TIJAN E., AKSENTIJEVIC S., IVANIC K., JARDAS M., *Blockchain Technology Implementation in Logistics*, in *Sustainability*, 2019, 11, p. 118.

[91] See CargoSmart, available at https://www.cargosmart.ai/en/.

‘*Smart contracts do not need a legal system for their existence they represent an alternative to the whole legal system*’

(SAVELYEV A., *Contract law 2.0*, 2017)

‘*Smart contracts are neither smart nor they are contracts*’

(LITAN A., in *Gartner*, March 3, 2020)

2. SMART CONTRACTS, THEIR NATURE AND SOME GENERAL REMARKS ON THE APPLICABLE LAW

SUMMARY: 2.1 The 'dilemma': what smart contracts are and what they are not – 2.2 Some general remarks on the applicable law in case of disputes arising from smart contracts, under an EU law perspective – 2.3 Current legal obstacles to smart contracts' scalability

The growing adoption of Bitcoin and other blockchain-based systems brought along a renewed interest and an increased experimentation in transforming legal agreements into code.

As anticipated in the previous section, 'blockchain 2.0' protocols (like Ethereum) provided the technology to implement some of the ideas described by Nick Szabo[92] over twenty years before on the possibility to use software to automatically execute contractual performance, without necessarily relying on any intermediary operator or 'trusted middleman'.

Under a legal perspective, the issues related to the nature and the value of smart contracts are among the most debated in literature.

For the purposes of this research project, I deem it opportune to devote this section to an analysis of smart contracts and the main legal issues that their implementation and diffusion could create in the practice.

In this vein, I will preliminarily try to ascertain if such computational models can be effectively considered '*contracts*'. Then, it will be possible to sketch some further considerations as to which contract law applies to them.

[92] SZABO N., *Smart Contracts* cit.

2.1 The 'dilemma': what smart contracts are and what they are not

Smart contracts embedded in a blockchain belong to the larger family of computable contracts, *i.e.* '*contracts which are directly written as a software*'[93].

In a nutshell, a smart contract is a self-executing protocol, whereby some terms of the agreement between two parties are written directly into code which activates itself when certain conditions occur in an '*if* … *then*' logic (*if* a circumstance occurs, *then* a predetermined consequence is executed).

As a starting point of this analysis, it must be considered that

a) smart contracts are first and foremost pieces of software that control, monitor, or document the execution of some legal obligations that have been created elsewhere[94], whose main aim is to produce certain legal effects between the parties involved, as predetermined by the parties themselves[95];

b) these protocols provide performance obligations that are not written in standard legal prose. Rather, such 'undertakings' are memorialised in the code using a formal programming language (e.g. Ethereum or Solidity);

c) once the wheels of a smart contract are put into motion, the terms embodied in the code will be executed and they cannot be stopped;

d) the front-end between the circumstances of the 'real' off-chain world and the 'digital' execution of smart contracts is guaranteed by a third-party

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[93] SANTOSUOSSO A., *About Smart Contract Dispute Resolution*, in CAPPIELLO B, CARULLO G. (eds.), *Blockchain*, *Law and Governance*, cit., p. 205.

[94] RÜHL G., *Smart (Legal) Contracts or: Which (Contract) Law for Smart Contracts?*, in CAPPIELLO B, CARULLO G. (eds.), *Blockchain*, *Law and Governance*, cit., p. 159; LOW K.F., MIK E., *Pause the blockchain legal revolution*, in *Int Comp Law Q*, 2020, 69, p. 135;

[95] Italian legislator has recently tried to define smart contracts as '*a computer program that operates on technologies based on distributed ledgers and whose performance automatically binds two or more parties on predetermined effects defined by them*' (article 8-*ter* of the Decree-Law no. 135/2018, converted into Law no. 12/2019).

source called 'oracle'[96]. Oracles can be individuals or programs that store and transmit information from the outside world, thereby providing a means for blockchain-based systems to interact with real-world events.

```
contract ToothFairy {
   address owner ;
   address mom = 0xd2dE66A09F48A96b8cd429951ca70F79715beBCc;
   address child = 0x80bFb3c5C9386e687936868A79f2e626F38a4AC2;
   bool paymentStatusToChild = false;
   enum ToothStatus {Mouth, WaitingForApproval, Fallen}
   ToothStatus public toothStatus;
   function ToothFairy() public payable {
      owner = msg.sender;
   }
   function () public payable {
   }
   function kill() public onlyOwner {
      selfdestruct(owner);
   }
   modifier onlyOwner {
      require(msg.sender == owner);
      _;
   }
   modifier onlyChild {
      require(msg.sender == child);
      _;
   }
   modifier onlyMom {
      require(msg.sender == mom);
      _;
   }
   function checkTooth() public onlyChild {
      require(toothStatus == ToothStatus.Mouth);
      toothStatus = ToothStatus.Fallen;
   }
   function momApproved() public onlyMom {
      require(toothStatus == ToothStatus.Fallen && paymentStatusToChild == false);
      child.transfer(this.balance);
      paymentStatusToChild = true;
```

Figure 7. Example of a smart contract (Source: BATTAGLINI R., *Blockchain and Smart Contracts*, Milano, 2019).

The above-mentioned features may constitute serious limits for the invoked widespread implementation of smart contracts to manage commercial arrangements.

Indeed, smart contracts are being designed to govern the transfer of digital currencies or tokens representing tangible or intangible assets, as well as to control access to data or other resources stored in a blockchain-based network. Thus, their function seems to be limited to automatically execute two types of transactions foreseen in an underlying 'physical' contract, such as (i) ensuring payments of funds upon certain triggering events and (ii) imposing financial penalties if certain objective conditions are not met.

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[96] See LIU A., *Smart Oracles: Building Business Logic with Smart Contracts*, in *Ripple*, July 16, 2014, available at https://ripple.com/insights/smart-oracles-building-business-logic-with-smart-contracts/; BUTERIN V., *Ethereum and Oracles*, in *Ethereum* (blog), July 22, 2014, available at https://blog.ethereum.org/2014/07/22/ethereum-and-oracles/.

An effective example of how smart contracts can support blockchain-based international trade can be imagined as a hypothesis of sale of goods: in such a decentralised marketplace, sellers can offer a product for sale by recording information in a blockchain (e.g., providing the description of the goods and their price); then, interested buyers can send money to a virtual escrow account implemented via smart contract which autonomously controls and manages any posted funds[97]. If everything goes as planned and the buyer receives the good, the buyer sends a digitally signed blockchain-based message to the escrow account, which then releases the amount of the purchase price to the seller. Conversely, if a dispute arises over the quality of goods or if the product never gets delivered, a predetermined human-based oracle can step in to analyse the facts and determine who should receive the escrowed funds[98].

Nevertheless, while smart contracts attempt in this way to govern legal transactions by using the slogan of '*code as law*' [99] as, such an approach is likely to be inappropriate in most cases, because such a model is consistent exclusively with a limited a set of promises that generally constitutes part of a larger (and often more complicated) contractual relationship.

In this sense, it must be born in mind that while there are some rights and obligations that are binary in nature and, therefore, easily transferable into the strict logic of code, other contractual provisions are not always clear-cut. In the

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[97] NARAYANAN A., BONNEAU J, FELTEN E., MILLER A., GOLDFEDER S., *Bitcoin and Cryptocurrency Technologies*, cit.

[98] '*Imagine, for the sake of illustration, that Alice finds a listing for a washing machine, offered by Bob for one bitcoin, through a blockhain-based marketplace. Once Alice is ready to make a purchase, she transfers one bitcoin to a smart contract-based virtual escrow account and communicates her shipping information to Bob. A few days later, when Alice receives the washing machine, she inspects it and – if satisfied with the product – sends a digitally signed blockchain-based message to the smart contract to release the bitcoin to Bob. The transaction is thus completed without the need of any trusted third party. If, however, the washing machine was defective or was never delivered, Alice can appeal to a third-party arbitrator (a human-based oracle) to retrieve her funds. Both parties would submit relevant information to the arbitrator, who would render a decision and release the escrowed funds either to Alice or Bob*', see *ibid.*

[99] SAVELYEV A., *Contract law 2.0: Smart Contracts as the beginning of the end of classic contract law.*, in *Inf Commun Technol Law*, 2017, 26, p. 116.

practice, legal agreements often include terms which are not binary nor suitable to for being executed into the strict logic of code, such as (i) open-ended and/or ambiguous terms that outline performance obligations (e.g., the duty to act in 'good faith' or 'best efforts' clauses); (ii) representations and warranties which cannot be fulfilled solely by referencing to data stored or managed within a blockchain-based network[100].

Thus, it is more likely that – at the most – parties of commercial transactions would opt for hybrid agreements blending natural-language clauses with smart contracts written in code to partially execute them[101]. This approach may allow natural language agreements and smart contracts to work together to execute parties' wills and intents, combining the advantages of both those instruments without necessarily having to choose one over the other[102].

In the light of the foregoing, it is possible to examine the further issue of whether smart contracts are effectively newly shaped regulations arising from private autonomy or are just a 'fancy name' to indicate mere protocols to transfer data, without constituting new and separate legal instruments[103].

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[100] '*Law firms are already assessing the limits of smart contracts in the context of legal arrangements. For instance, the large international law firm Hogan and Lovells created a "smart" earthquake insurance agreement. They built a digital term sheet outlining key terms in this agreement and modeled and Ethereum-based smart contract … to govern relevant payouts. After running the experiment, however, the firm quickly realized that an entirely code-based program could not account for standard conditions typically included in a basic earthquake insurance agreement*', see DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 77-78, referring to NORTON S., *Law firm Hogan Lovells Learns to Grapple with Blockchain Contracts*, in *WSJ.com*, February 2, 2017, available at http:/blogs.wsj.com/cio/2017/02/01/law-firm-hogan-lovells-learns-to-grapple-with-blockchain-contracts/.

[101] The so-called '*Ricardian Contract*', proposed by Oliver Goodenough from Vermont Law School, can be considered as an example of this convergence: it was intended to be a contract whose expression was both executable by a computer and understandable by a human reader, with a mixed format of text and code. See GOODENOUGH O.R., *Integrating Smart Contracts with the Legacy Legal System: a US Perspective*, in CAPPIELLO B, CARULLO G. (eds.), *Blockchain*, *Law and Governance*, cit., p. 191.

[102] DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 78.

[103] BERTOLI P., *Smart (Legal) Contracts: Forum and Applicable Law Issues*, in CAPPIELLO B, CARULLO G. (eds.), *Blockchain*, *Law and Governance*, cit., p. 181.

Some considerations lead to the conclusion that the truth probably lies somewhere in between the radical options just mentioned.

Firstly, smart contracts constitute autonomous and self-sufficient legally binding agreements if and to the extent that they translate into digital code 'real' agreements already concluded between parties in the off-chain world, subject to the law applicable thereto[104].

Once agreed upon, parties need to translate all or part of their promises in smart contract code, which is triggered by digitally signed blockchain-based transactions. In this sense, smart contracts will require the will of the parties in order to become effective, just any other contract; moreover, the perspective that it is impossible to breach a smart contract because the code is immutable and self-executing, whether accurate in all respects or not, does not *per se* limit the possibility and need of judicial assistance.

Secondly, it is possible to argue that smart contracts promise nothing less than automatic execution of legal obligations and, hence, they need a legal system to determine whether there is any enforceable (and validly created) legal obligation to begin with.

If a dispute on smart contracts' accuracy in representing parties' intent or on potential breach of contract arises, the contracting parties still retain the possibility to bring legal proceedings before the 'physical' court with jurisdiction over the legal effects of the underlying contract. Then, the competent Court will probably evaluate the case according to long-standing principles of contract law[105].

[104] DE CARIA R., *The legal meaning of smart contracts*, in *Eur Rev Priv Law*, 2019, 6, p. 731; CAPPIELLO B., *Dallo "smart contract" computer code allo smart (legal) contract. I nuovi strumenti (para) giuridici alla luce della normativa tradizionale e del diritto internazionale privato europeo: prospettive de iure condendo*', in *Riv. Comm. Int.*, 2020, p. 477.

[105] According to some scholars '*Even if a smart contract allows for an alternative dispute resolution system based on a third-party oracle, the court could invalidate any adjudication done by the oracle; for instance,*

In the light of the above, the real issue about smart contracts seems not to be whether smart contracts are subject to law or whether they are perfectly overlapping with traditional contracts, but rather which law they are subject to.

In the following paragraph, I will try to sketch some preliminary answers to this question.

2.2 Some general remarks on the applicable contractual law in case of disputes arising from smart contracts, under an EU law perspective

Traditionally, the issue of which law applies to a contract is determined by the rules of private international law[106].

With reference to smart contracts, scholars pointed out that these 'digital protocols' are particularly hard to assign to a legal system or another, especially when they are stored and enforced in a blockchain-based network, in the light of the fact that blockchain transactions are basically conducted simultaneously on computers scattered around many different jurisdictions. According to this thesis, '*what makes the regulation of smart contracts particularly complex is their cross-border nature, given that they are generally operated by different computers located in different jurisdictions. This may make it more difficult to identify the law applicable to the contract*'[107].

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if the arbitrator failed to comply with the arbitration provision or manifestly disregarded the law', see DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 79, recalling US arbitration case law on the possibility for courts to set aside arbitration awards for '*manifest disregard of law*'. On this specific point, see *inter alia* RUBINS N., *Manifest Disregard of the Law and Vacatur of Arbitral Awards in the United States*', in *American Review of International Arbitration*, 2001, 12, p. 363.

[106] For a general overview see *inter alia* BASEDOW J., RÜHL G., FERRARI F., DE MIGUEL ASENSIO P. (eds.), *European Encyclopedia of Private International Law*, Celtenham (UK) – Northampton (MA – USA), 2017.

[107] See DUROVIC M., *Law and autonomous systems series: how to resolve smart contracts dispute – smart arbitration as a solution*, available at https://www.law.ox.ac.uk/business-law-blog/blog/2018/06/law-amd-autonomous-systems-series-hw-resolve-smart-contracts-disputes/, as recalled by RÜHL G., *Smart (Legal) Contracts*, cit. On this specific point, see also WOEBBEKING M.K., *The impact of smart contracts on traditional concepts of contract law*, in *J Intellect Prop Inf Technol Electron Commer Law*, 2019, 10, p. 105.

Although, even in the light of the considerations set out in the previous paragraph, the process for identifying the applicable law to smart contracts seems in fact not to be particularly dissimilar to those that are posed by traditional contracts.

Before moving to a deeper analysis of this issue, two general premises must be unfolded.

First of all, the following analysis will be carried out under a EU perspective, aiming at discussing which contract law may apply to smart contracts if courts of a EU Member State have to determine the applicable law in a dispute arisen between EU parties[108].

Moreover, the analysis will focus exclusively on the relationship between the immediate parties of a smart contract and will not evaluate the further relationship they may have with the other 'nodes' of the blockchain, nor which law applies to the blockchain infrastructure as such[109].

Finally, it must be noted that

a) blockchain-based smart contracts are designed to involve actors scattered across various jurisdictions. Thus, they integrate the requirement of the '*connection to a foreign county*'[110] for private international law to come up;

b) despite the connection to a foreign country, there may be no need to apply the rules of EU international private law where uniform substantive law applies, such as the provisions of international trade

[108] For an analysis of a US law perspective, see GOODENOUGH O.R., *Integrating Smart Contracts*, cit., p. 191; DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 79.

[109] For an overview of the problems of applicable law associated to blockchain technology, see DICKINSON A., *Cryptocurrencies and conflict of laws*, in FOX. D., GREEN S. (eds.), *Private and public law implications of cryptocurrencies*, Oxford, 2019, p. 93; LEHMANN M., *Who owns bitcoin? Private law facing the blockchain*, in *Minnesota J Law Sci Technol*,2019, 21, p. 93.

[110] See *inter alia* WELLER M., *Article 1 Rome 1*, in CALLIESS G.P. (ed.), *Rome Regulations*, Alphen aan den Rijn, 2015.

generally governing international contracts. By way of the example, this could be the case of (i) the United Nations Convention on Contracts for the Sale of Goods of April 11 1980 (CISG)[111], which would probably govern international smart contracts for the sale of goods where concluded between parties having their seat in different contracting states (see article 1 of the CISG); (ii) the international conventions that set out the uniform law for international transport[112], such as the Convention on the Contract for the International Carriage of Goods by Road (CMR) of May 19 1956, the Convention for the Unification of Certain Rules for International Carriage by Air of 28 May 1999, or the Convention concerning International Carriage by Rail (COTIF). In all these cases, EU private international law will become relevant to the extent that the above-mentioned sources of uniform substantive law contain gaps to be filled[113].

Without prejudice of the above, if an issue of private international law had arisen before courts located in the EU and dealing with smart contracts regulation, the latter would usually look to the so-called Rome I Regulation[114] and to the uniform choice of law rules set therein.

Indeed, while smart contracts are *per se* probably not eligible to set out '*contractual obligations in civil and commercial matter*', as requested by Article 1(1) of the Rome I Regulation[115], their current state-of-the-art allows to argue that such

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[111] For an overview, see *inter alia* FERRARI F., *CISG*, in BASEDOW J., RÜHL G., FERRARI F., DE MIGUEL ASENSIO P. (eds.), *European Encyclopedia of Private International Law*, cit., p. 338.

[112] For an overview, see *inter alia* DAMAR D., *Transport law (uniform law)*, *Ibid.*, p. 1726.

[113] RÜHL G., *Smart (Legal) Contracts*, cit., p. 165.

[114] Regulation (EC) no. 593/2008 of the European Parliament and of the Council of 17 June 2008 *on the law applicable to contractual obligations (Rome I)*, OJ 2008 EU L 177/6. For an overview, see HARTLEY T.C., *International commercial litigation*, Cambridge, 2015; MOSCONI F., CAMPIGLIO C., *Diritto Internazionale Privato Processuale – Parte generale e obbligazioni*, Milano, 2010; LANDO O., NIELSEN P.A., *The Rome I Regulation*, in *Common Mark Law Rev*, 2008, 45, p. 1687.

[115] For exceptions, see Article 1(2) of Rome I Regulation.

a regulation shall apply to the contractual obligations that smart contracts may help to execute, monitor and/or document.

The situation might, however, be the opposite if the obligation itself was directly undertaken through algorithms and fully embodied in the code: in this case, indeed, it would be questionable whether such an obligation would be '*freely assumed*' by one party, as requested by the CJEU to acknowledge a '*contractual obligation*' under the Rome I Regulation[116]. Nevertheless, such a scenario remains a theoretical exception for the time being and then the following analysis will consider the rules set out in the Rome I Regulation to determine which law is applicable to smart contracts (rather, to the legal obligations they help to execute).

First of all, to apply the Rome I Regulation means determining the applicable law through the principle of party autonomy set out by Article 3 of the Regulation itself. As regards to smart contracts, such a principle allows the parties to establish a connection to a specific legal system even if the smart contract operates in a completely virtual and completely decentralised manner.

Here, the paramount question is: how the parties of a smart contract can choose the applicable law, which can hardly be represented in algorithmic terms?

It has already been highlighted that, so far, it is likely that parties of commercial transactions will opt for hybrid agreements blending natural-language clauses with smart contracts written in code to partially execute them. When the smart contract is concluded in natural legal terms and the computer protocol merely assist the performance of the contractual obligations, the

[116] See ECJ, C-26/91, *Handte/TMCS*, ECLI:EU:C:1992:268, para. 15; ECJ C-51/97, *Réunion européenne SA/Spliethoff's Bevrachtingskantoor BV*, ECLI:EU:C:1998:509, para. 17; C-334/00, *Tacconi/Wagner*, ECLI:EU:C:2002:499, para. 12; C-265/02, *Frahuil/Assitalia S.p.A.*, ECLI:EU:C:2004:77, para. 24; C-359/14 and C-475/14, *ERGO Insurance /If P & C Insurance*, ECLI:EU:C:2016:40, para. 44.

relevant choice of law should be expressed in the agreement. Otherwise, for the (futuristic) scenario in which smart contracts will be exclusively concluded via blockchain technology or represented in an '*algorithmic way*', the choice of law clause may be difficult to be incorporated into the contract and may have to be expressed in a separate declaration[117].

Likewise, implied choices of law may be hard to establish in smart contracts: indeed, article 3(1) of the Rome I Regulation requires that the implied choice is '*clearly demonstrated*' by the terms of the contract or the circumstances of the case. In the context of smart contracts such an intention will often be missing, requiring Courts to turn to either (i) Article 4 of the Rome I Regulation and its principle of '*closest connection*'[118], notably declined through eight specific choice of law rules, two residual rules and one escape clause[119] (*i.e.* the law of the state '*manifestly more closely connected*' to the contract, to be determined by gathering all existing connections as compared to others: this can be difficult as the location of the 'nodes' of a blockchain seems arbitrary); (ii) Articles 5-8 of the Rome I Regulation, setting out specific choice-of-law rules protecting weaker parties in the context of contracts of carriage, consumer contracts, insurance contracts and employment contracts.

These rules do not seem to pose huge issues of application to smart contracts, at least as they are concluded in the above-mentioned traditional or 'hybrid' way: as complicated the application of the Rome I Regulation may be for smart contracts, at the end of the day it will allow practitioners to say which laws applies. Indeed, Article 4 of the Rome I Regulation mostly relies on the

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[117] BERTOLI P., *Smart (Legal) Contracts*, cit., p. 188.

[118] For an overview see RÜHL G., *Smart (Legal) Contracts*, cit., p. 169.

[119] See REMIEN O., *Closest connection and escape clauses*, in LEIBLE S. (ed.), *General principles of European Private International Law*, Alphen aan den Rijn, 2016, p. 211. In the ECJ case law, see C-305/13, *Haeger & Schmidt GmbH/Mutuelles du Mans Assurances IARD*, ECLI:EU: C:2014:2320, para. 49.

habitual residence of one of the parties as a connecting factor, which is able to link even completely virtual smart contracts to a particular national law.

Nevertheless, '*it may happen that the habitual residence of the relevant party cannot - or only with difficulty - be determined because the smart contract is processed anonymously - or pseudonymously - via a blockchain. In all of these cases the applicable law will have to be determined in accordance with Article 4(4) Rome I Regulation. And, naturally, this will neither be an easy task, nor will it always lead to entirely convincing or foreseeable results'*.

Two preliminary conclusions can be drawn from the above.

Firstly, even under this profile, the desirability of concluding 'hybrid' smart contracts as defined above seems at present not easily to set aside and, moreover, it would probably be the most immediate mean to implement smart contracts in the practice.

Secondly, and consequently, 'smart contractual parties' will tend to indicate the systems of law that will be best equipped to meet the challenge of digitalization. This is also why some countries, such as the UK, Germany, Italy and the Netherlands[120], have already started to think about whether they respective national laws are providing a legal environment for smart contract and, therefore, are laying the foundations for a more pervasive regulation in this sense.

Thirdly, the smart contracts' pseudonymity continues to intuitively represent an issue not only for the purposes of applicable law, but also for their scalability.

The final part of this section will be dedicated to with a quick recap of the drawbacks that still exist with reference to smart contracts.

[120] See VOLOS A.A., *The technology of Blockchain an Smart Contract and their regulation under the conflict of laws of the European Union*, in *Advances in Economics, Business and Management Research*, 2020, 156, p. 563.

2.3 Current legal obstacles to smart contracts' scalability

A. Confidentiality and privacy concerns

When parties enter in an agreement written in legal prose, they generally have the possibility to keep its terms confidential. This cannot be the case of smart contracts, that are transparent per nature, propagated across a peer-to-peer network and, therefore, publicly visible to all the nodes of the network.

The above could create possible confidentiality and privacy risks, especially when the parties transacting on a blockchain are associated with known entities; moreover, even when the parties are hidden behind pseudonymous accounts, they may struggle to conceal their identity.

These issues may limit the potential of smart contracts to replace traditional legal contracts in many commercial settings, where confidentiality is crucial[121].

B. The impossibility to define complex legal obligations

Moreover, ad as already mentioned, smart contracts will not likely to be useful for arrangements with vague or open-ended provisions, that cannot be translated in programming language.

Indeed, '*smart contracts are not particularly well suited to accommodate legal arrangements that are relational in nature. To implement a smart contract, parties need to precisely define performance obligations and, if they rely on human-based oracles, instances where human insight is required*'[122].

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[121] KOSBA A., MILLER A., SHI E., WEN Z., PAPAMANTHOU C., *Hawk: the blockchain model of cryptography and privacy-preserving smart contracts*, in LOCASTO M., SHMATIKOV V., ERLINGSSON U. (eds.), *2016 IEEE Symposium on Security and Privacy (SP)*, Piscataway (NJ – USA), 2016, p. 839.

[122] DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 84.

In other terms, in many commercial relationships smart contracts could not be able to provide the parties with the flexibility to structure their ongoing contractual relationship.

Besides, it has to be considered that, in this context, programmers (and not legal practitioners) will need to translate in digital means subjective judgments, interpretations and substantive decisions about potentially uncertain future events when drafting smart contract codes, which could effectively distort the parties' intent.

This can lead to huge problems not only in the negotiation phase of the contractual relationship, but also in its execution, considering that smart contracts are also designed to be immutable, once executed. And smart contracts' possible conversion in tools to create immutable consequences contrary to the will of the parties could determine the ultimate death of these protocols.

C. Pseudonymity

Moreover, contractual amendments and/or enforcement may be very limited by parties' pseudonymity. It has already been described above how such a feature can potentially undermine the diffusion of smart contracts.

D. Contractual standardization

Finally, it has been emphasized that a widespread adoption of smart contracts may accelerate changes in the delivery of legal services, resulting in a '*structural shift of the legal profession*' which may lead people to rely less on the advice of lawyers in favour of standardized agreements incorporated in smart contracts.

This would be a new practical application of the phenomenon known as '*automation bias*', by which people tend to trust computer-generated recommendation systems more than other sources of information[123].

The consequence would be that, with the greater availability of standardized libraries of codified smart contracts, some details and subtleties of the current legal work could be lost. Indeed, these 'libraries' are unlikely to perfectly match the specificities of each commercial and legal arrangement and, therefore, contracting parties could risk using '*default provisions*'[124] without considering whether they precisely fit their legal needs.

This is another hint to conclude that smart legal contracts may well evolve and become more popular, but it is unlikely that they will replace traditional contracts, because they are by design not able to replicate the entire spectrum of human decision-making in the development of contractual practices[125].

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[123] BAHNER J.E., HUPER H.D., MANZEY D., *Misuse of Automated Decision Aids: Complacency, Automation Bias and the Impact of Training Experience*', in *International Journal of Human-Computer Studies*, 2008, 66 (9), p. 688.

[124] See MCGINNIS J.O., PEARCE R., *The Great Disruption: How Machine Intelligence Will Transform the Role of Lawyers in the Delivery of Legal Services*, in *Fordham Law Review*, 2014, 82, p. 3041; DAVIS K.E., *The demand of immutable contracts: another look at the law and economics of contract modifications*, in *New York University of Law Review*, 2006, 81, p.487. According to the latter, '*In light of the cognitive and economic constraints that limit parties' ability to draft complex contracts, they will be unable to draft an agreement that is sufficiently immutable to generate significant ex post gains from trade. In other words, sometimes it may be not only prohibitively costly to adopt a contract that is completely immutable (i.e., in all circumstances) but also impossible to draft a partially immutable contract that successfully defines and distinguishes circumstances in which modifications should and should not be permitted*'.

[125] GÒMEZ M.A., *The chimera of smart contracts*, in HUTCHINSON A., MYBURGH F., *Research Handbook on International Commercial Contracts*, Celtenham (UK) – Northampton (MA – USA), 2020, p. 328.

'Shipping a container from Mombasa to Rotterdam
still generates a pile of paper that is twenty-five cm. high'

(GANNE E., *Blockchain for Trade: when Code needs Law*, 2021)

3. *UTOPIA* OR REALITY? BLOCKCHAIN ADOPTIONS IN THE '*LOGISTICS 4.0*'

SUMMARY: 3.1 Blockchain technology: a cornerstone of '*Logistics 4.0*' – 3.2 Blockchain technology and its potential suitability to address some of the critical issues of the logistics and maritime industry – 3.3 *Trust is all you need*: the analogies between blockchain's purposes and the industry's demands – 3.4 The industry's attempt to implement blockchain-based tools and the blockchain 'paradox'

It has been described in the previous sections that a blockchain is, in a nutshell, a chain of blocks (or transactions) linked to one another using cryptography and time stamping, with a subsequent high level of security and immutability of the data stored therein.

Not surprisingly, these requirements caught the attention of the logistics and transportation industry, lured by the opportunity to track the journey of products and/or documents along the entire supply chain through a digital ledger which might be able to act in compliance with the highest standards of transparency and traceability.

Moreover, in the light of its immutability and traceability features, blockchain may offer the guarantee that the electronic documents exchanged therein are authentic and have not been already 'spent' on the market. This feature can, on the one hand, open great opportunities to digitize trade documents and, on the other hand, prevent hypothesis of double spending[126], which is a common source of fraud in international trade.

Finally, the huge number of stakeholders involved in international trade has lead scholars and practitioners to analyse (often in too emphatical terms) the opportunities that blockchain can open to facilitate interaction and

[126] GANNE E., *Blockchain for trade: when Code needs Law*, in *AJIL Unboud*, 2021, 115, p. 419.

reconciliation across the supply chain, as well as its capacity to generate trust among the parties involved.

The aim of the present section is to provide an overview of blockchain potentials in this sector of industry and, at the same time, to critically evaluate the possible challenges yet to be meet by the technology to definitively gain a foothold in the day-to-day relevant operational processes along the supply chain.

While standardization and technical interoperability have been the focus of attention by the stakeholders so far, in the forthcoming it will be explained how the lack of both legal clarity and regulatory framework might be seen as the main challenge to deal with for the deployment of blockchain solutions in international trade.

At the end of the day, digital tools only provide a tool to move toward an structured 'dematerialisation' of the business at stake and its practices. Therefore, they can be used as far as the legal framework recognizes them as legally binding instruments to develop human commercial relationships and exchanges.

This does not seem to have happened yet in the world of international trade.

3.1 Blockchain technology: a cornerstone of the so-called '*Logistics 4.0*'

Despite operating in an historically conservative sector of industry[127], stakeholders of the logistics market are making great efforts to embrace the so-called 'Industry 4.0'[128].

[127] BAVASSANO G., FERRARI C., TEI A., *Blockchain: How shipping industry is dealing with the ultimate technological leap*, cit.

[128] PU S., SIU LEE LAM L., *Blockchain adoptions in the maritime industry: a conceptual framework*, cit.

Indeed, in a global scenario interested in researching industrial automation through highly specialized cybernetic systems integrating each other, an extensive connectedness of processes may (i) allow machines, warehousing systems, logistics equipment and products to exchange information, prompt autonomous actions and enable same to control one another's activities; (ii) grant, on the one hand, complete transparency within the supply chain (*i.e.*, from supplier to customer) and, on the other hand, enable decentralized management[129]; (iii) provide the stakeholders with practical means to face the emerging challenges of international trade, such as increasing protectionism, tightening environmental regulations and, last but not least, the recent outbreak of Covid-19 pandemic[130].

In the light of the above, it is a common feeling that the world of logistics is in the middle of a new revolutionary phase, as in the late 19th Century with the mechanisation of transport or in the 1960s with containerisation[131], or again in the 1980s when computers entirely restructured business models relevant to the specific sector.

This further evolutionary process, identified as '*Logistics 4.0*', is driven by several different innovations aimed at enabling a smart management of

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129 RADIVOJEVIC G., MILOSAVLJEVIC L., *The concept of logistics 4.0*, *4th Logistics International Conference*, 2019; WANG K. *Logistics 4.0 solutions*, in *Proceedings of the 6th International Workshop of Advanced Manufacturing and Automation*, 2016, available at https://www.atlantis-press.com/proceedings/iwama-16/25862222.

130 According to the WTO report of November 2020 of the diffusion of DLT in the supply chain industry, '*COVID-19 has uprooted processes and established outlooks in many industries around the world … the vast majority of firms have experienced a positive benefit to their DLT plans and activities as a result of the pandemic. Without the physical presence of staff, due to work-from-home orders in many nations around the world, banks and corporates have been forced to produce rapid digital solutions in order to remain operational. In many instances, according to a report by the ICC Digitalisation in Trade Finance Working Group titled 'Digital Rapid Response Taken by Banks Under COVID-19', this was best done by scaling up existing digital solutions*' (see TRADE FINANCE GLOBAL AND WORLD TRADE ORGANIZATION, *Blockchain and DLT in Trade: where do we stand?*, cit., p. 20).

131 CUDAHY B., *Box Boats: How Container Ships Changed the World*, New York, 2006; LEVINSON M., *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*, Princeton, 2006.

processes through, *inter alia*, automatic identification, real-time location, automatic data collection, connectivity and integration between technologies[132].

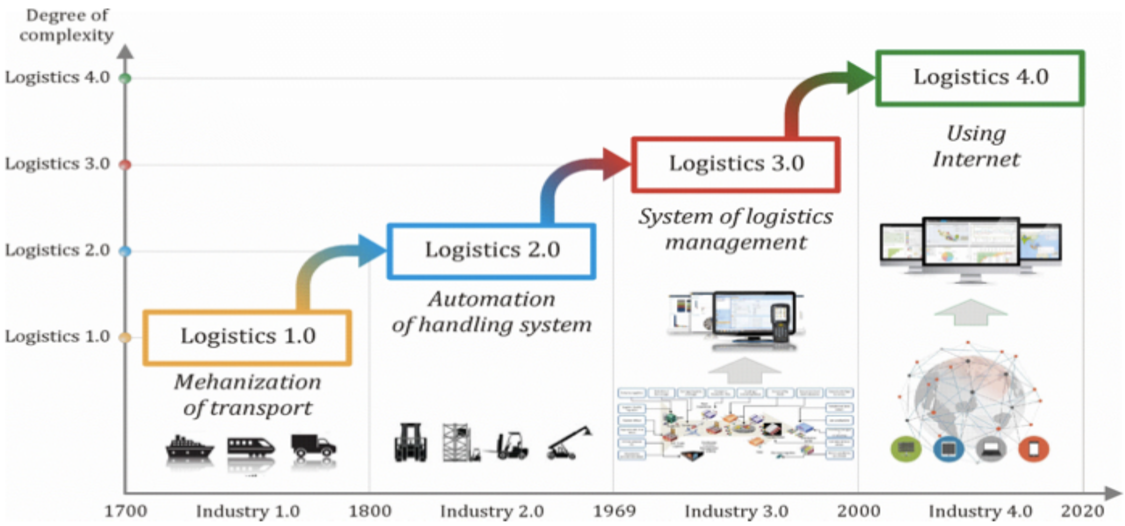

Figure 7. (Source: WANG K., *Logistics 4.0 Solution New Challenges and Opportunities*, in *proceedings of the 6th International Workshop of Advanced Manufacturing and Automation – IWAMA*, 2016, p. 68).

Among the pillars of Logistics 4.0 (e.g., Internet of Things, Cloud Computing, Big Data, Robotics and Automation and 3D Printing), blockchain technology is a cornerstone of the system: in order to face the continuing growth of world seaborne trade[133] and its impact on their business processes, the players of the maritime industry have gradually started to develop and test pilot projects based on blockchain, which has been triumphantly described[134] as likely to become the 'software' for the further facilitation of international trade, in the same way as shipping containerisation provided the 'hardware' for its definitive enshrinement.

[132] WANG K. *Logistics 4.0 solutions*, cit.; EL-NAHRAWY A., *Fourth Industrial Revolution and its impacts on world seaports and logistics centers*, in *Acts of the International Maritime and Logistics Conference "Marlog 9"*, 2020, March 29-31.

[133] UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE (UNECE), *White Paper on Blockchain in Trade Facilitation – Version 2*, cit., p. 58.

[134] GANNE E., *Can blockchain revolutionize international trade?*, cit., p. 44.

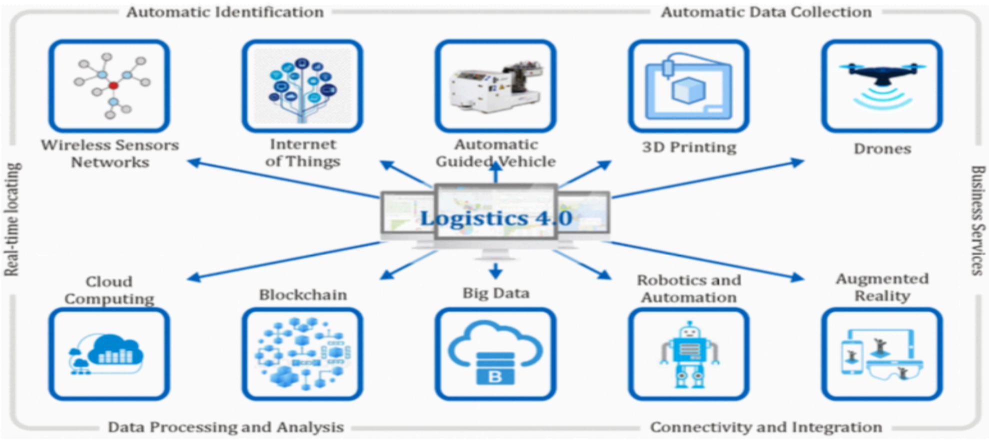

Figure 8. (Source: RADIVOJEVIC G., MILOSAVLJEVIC L., *The concept of logistics 4.0, 4th Logistics International Conference*, 2019).

The reason of such a huge interest that maritime industry has been showing to blockchain technology is, probably, twofold, and it will be explained in the next paragraphs.

3.2 Blockchain technology and its potential suitability to address some of the critical issues of the logistics and maritime industry

As illustrated in the previous sections, blockchain is, by-design, a means to develop multi-party interchanges and connections in a transnational context.

In the light of these features, it can be considered as particularly suitable to overcome the challenges and, therefore, to match the needs of the logistics sector. Barring expectations of exhaustiveness, some synthetic remarks can clarify such a point.

As a preliminary remark, it is necessary to consider that maritime trade involves a range of different players. According to a United Nations Economic Commission for Europe ('UNECE') paper of October 2020, '*On average, both in the country of origin and in the country of arrival, about 40 parties/companies play defined roles in the transport and logistics flow. For one roundtrip, on average, a cargo vessel will call* *in at 5 load and 5 discharge ports and a total of 1,000 active users will be involved in the total transport and cargo flows*'[135].

In this context, goods, services, documents and – more generally – information are daily exchanged between the numerous parties involved. Keeping track of all these transactions is extremely complicated and paper-intensive, especially because businesses deploy multiple ledgers within multiple networks. Nowadays, though most records are electronic, they often rely on physical data and are stored in different computer systems located on different company premises and departments[136].

As a result, these records often require time consuming and, sometimes, manual interventions to ensure that they are properly reconciled (e.g., ensuring that all goods ordered were shipped, that all shipped goods were invoiced and all invoiced goods were paid, etc.)[137].

This is the main reason why blockchain implementation is still expected to play a significant role in the digital transformation of crucial operations and related commitments of the parties involved[138], having the potential to increase transparency and availability of information for all participants, albeit subject to commercial data confidentiality guaranteed by cryptography[139].

By way of an example, parties to a commercial transaction (such as the seller, the buyer or a bank) may simply consult their copy of a shared ledger to see

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[135] UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE (UNECE), *White Paper on Blockchain in Trade Facilitation – Version 2*, cit., p. 58.

[136] It has been stated that in several jurisdiction (such as in the UK) such a process is also due to the notion of 'possession' that is attached to tangible things and excludes that an intangible thing (like e-documents) can give rights simply by virtue of their holding, see GANNE E., *Blockchain for trade*, cit., p. 422

[137] UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE (UNECE), *White Paper on Blockchain in Trade Facilitation – Version 2*, cit., p. 44.

[138] PHILIPP R., PRAUSE G., GERLITZ L., *Blockchain and smart contract for entrepreneurial collaboration in maritime supply chains*, in *Transports and Telecommunication*, 2019, 20 (4), p. 365.

[139] CHRISTIDIS, K., DEVETSIKIOTIS M., *Blockchains and Smart Contracts for the Internet of Things*, in *IEEE Access*, 2016, 4, p. 2292.

what the current status of shipment is or to check information relating to the transaction itself. Then, payment automation resulting from using smart contracts can reduce payments delays and disputes, integrating financial service providers into the supply chain, as well as the transparency granted by blockchain could be used to reduce the costs and the mistakes related to the manual processing[140].

Despite increasing trustworthiness among parties beyond the correctness of the documents[141], such a system may well affect the way some of the numerous intermediaries (e.g., ship-agents, customs-agent or brokers) involved in a shipment nowadays work.

A significant example can be provided looking to a simplified charter-party contracting process within a single voyager in the fright market[142].

As is generally known, the general charter-party contracting process comprises four phases, such as (i) pre-fixture, (ii) fixture, (iii) post-fixture loading and (iv) post-fixture discharging of goods. In all of these phases, several intermediaries are involved, such as (i) shipbrokers that generally reconcile the charterer and the shipowner's interests, allowing the circulation of information between them; (ii) port agents appointed at the importing and exporting port for locally representing the parties and monitoring *inter alia* stevedores, bills of lading, notice of readiness statement and vessel's statement of facts in both the loading and discharging phases; (iii) potentially, lawyers appointed in case of disputes arising from the charter-party and its performance and (iv) judges, in the event that these disputes are not settled out of court.

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[140] MAREKNOVIC S., TIJAN E., AKSENTIJEVIC S., *Blockchain Technology Perspectives in Maritime Industry*, paper presented at the *44th International Convention on Information, Communication and Electronic Technology (MIPRO)*, Opatija – Croatia, September 27- October 1, 2021, p. 1414.

[141] BECK R., *Beyond Bitcoin: The Rise of Blockchain World*, in *Computer*, 2018, 51 (2), p. 54.

[142] See PHILIPP R., PRAUSE G., GERLITZ L., *Blockchain and smart contract*, cit., p. 369.

Many options for enhancements of such a general charter-party situation may effectively be partly empowered through the implementation of the blockchain or smart contract technology, respectively.

Firstly, the 'pre-fixture phase 4.0' (*i.e.* when the charterer is looking for a suitable vessel and the ship-owner searches for freight that needs to be transported from an origin to a destination port) could be eased by a virtual marketplace implemented on the blockchain technology, with additional smart contract applications. Here, a smart contract application could compare the shared initial data from charterers and ship-owners that is provided on a web-based marketplace platform, and thus, can automatically check whether the pre-conditions for a match are fulfilled. Building upon this, a kind of pre-contracts can be automatically generated as well by the smart contract application, since the shared data of the participants represents at the same time the initial information and pre-conditions that must be fulfilled for the aspired development of a charter-party contract.

Secondly, in the following 'fixture phase 4.0' (*i.e.* once the charterer and the ship-owner have jointly agreed on the rates and terms of the charter-party) the agreement could be fixed and automatically generated through an underlying smart contract application. Besides, such an elaborated and fixed charter-party contract would be stored and secured on the blockchain, becoming decentralised, secured, fraud-resistant, immutable, transparent and permanently auditable and accessible for all involved stakeholders during the cargo voyage – if permission is granted.

Thirdly, in the 'loading and discharging 4.0' phases, the respective information about the loading activities in the origin port and the discharging activities in the port of destination could be uploaded and stored on the blockchain in real-time through the additional incorporation of IoT applications (such as smart devices). Therefore, all necessary information or documents, respectively, would become decentralised secured, fraud-resistant, immutable, transparent and permanently auditable and accessible for all involved parties. Moreover, and since smart contracts can read from and write on the blockchain, important documents like vessel's statement of facts or bills of lading can potentially be automatically elaborated by an implemented smart contract application, granting the automatic payment of the ship-owner for his services.

In theory, all the above seems able to finally reduce the possibility of disputes between the parties, avoiding or, at least, limiting the involvement of lawyers and/or courts.

If, at the moment, all of the above can reasonably be considered as still utopian, this is exactly what the stakeholders involved in the process of testing blockchain in the maritime sector are aiming at.

That being said, there is another reason why technologies of the 'Industry 4.0', and especially blockchain, are looked at with such great interest by the participants of the so-called 'supply chain'.

Indeed, the current processes for the exchange and transportation of goods regularly faces regulations and compliance rules enforced by humans, which are intuitively less predictable than the above-prospected review of digitalized documents by mere information systems.

Nevertheless, through an implementation of blockchains and smart contracts, transport information may potentially establish an algorithmic-compliance-checking system which would be continuously updated to the most recent rules and regulations.

In such a scenario, information for a transaction may also be accessed by regulators and, if the compliance check is approved, the transaction may proceed more smoothly. According to the International Transport Forum, ‘*Establishing a tamper-evident shared database for supply chains could simplify bureaucratic tasks and ease the burdens of enforcement. Protocols for customs checks, vehicle registration, last-mile delivery, and fuel quality verification could all be improved. Scandals around product recalls, unethical sourcing, inaccurate emissions data and package theft could be avoided, helping regulators save time and resources through a reduction of complaints, legal disputes, pollution and public pressure … Similar to how medical resources are better spent on preventing disease rather than treating it, DLTs could facilitate enforcement that prevents future fallout from illegal activity*’[143].

Accordingly, the WTO has expressed the need also for regulators to develop an understanding of how blockchain works and, therefore, establish regulatory framework that enable and support the technology where appropriate[144].

This would determine a drastic improvement over currently implemented regulatory systems[145] and, more generally, it may come up as a real ‘revolution’ of how the operators of the sector currently interact each-other, as the following figure clearly shows.

143 INTERNATIONAL TRANSPORT FORUM, *Forging Links – Unblocking Transport with Blockchain?*, 2021, available at https://www.itf-oecd.org/sites/default/files/docs/forging-links-unblocking-transport-blockchain.pdf.

144 ‘*By participating in DLT pilots and consortia with the private sector, regulators can gain experience with DLTs and ensure that desired policy outcomes are incorporated into platform governance and smart contracts from the beginning. They can also undertake their own low-risk, small-scale pilots to better grasp the utility and challenges of deploying DLTs. Such public sector interest and investment in DLTs could give the private sector the confidence to continue exploring the technology's potential, and allay fears that an eventual scaled-up platform would be rejected by regulators*’, see *Ibid.*

145 UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE (UNECE), *White Paper on Blockchain in Trade Facilitation – Version 2*, cit., p. 64.

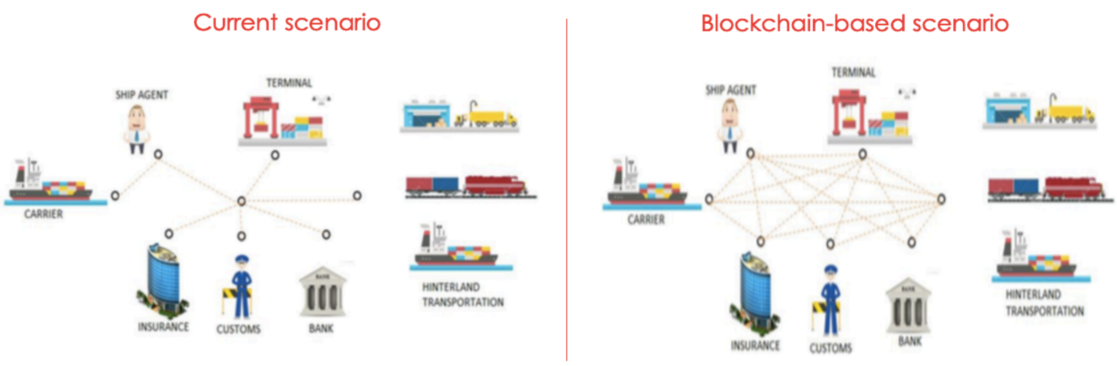

Figure 9.

However, and as it will be described below, these prospects are still far from being realised, due to the huge challenges that still characterise blockchain technology and its diffusion even in the logistics sector.

3.3 *Trust is all you need*: the analogies between blockchain's purposes and the industry's demands

Another interesting aspect must be mentioned in a comprehensive and multidisciplinary analysis of the factors that may have led to the rise of a considerable hype for blockchain technology in the logistics and shipping industry.

As scholars have already argued, the booming of blockchain-based projects in the logistic sector is probably due to the analogies between the features underlying such technology and the needs underpinning the implementation of both praxis and regulations inherent in the 'traditional' transport and logistics operations (e.g., resistance to tampering, decentralisation, plurality of parties involved) [146].

As it will be illustrated in more detail in the final section of this paper, the proximity between the goals of the new technology and the needs of maritime

[146] MUNARI F., *Blockchain and smart contracts in shipping and transport. A legal revolution is about to arrive?*, cit.; TAKAHASHI K., *Blockchain technology and electronic bills of lading,* in *The Journal of International Maritime Law*, 2016, 22, p. 202.

transport can be considered as a decisive factor in making the stakeholders overcome their traditional reluctance to develop new tools for conducting their business.

Such a conclusion leads to further queries on whether it is possible to consider an allegedly self-standing set of unwritten rules, such as the already identified *lex cryptographica*, as a digital version of the *lex mercatoria* regulating through the centuries the commercial relationships between maritime industry players on a transnational level.

Should the reply be yes, one could ask oneself whether the current regulatory and customary framework is suited to grant the execution and enforcement of pure 'digital' rights even in the 'physical' world we are living in.

The following section of the thesis will try to sketch some preliminary answers to the questions set out above.

Before doing so, it seems nevertheless necessary to take a preliminary and closer look at the practical applications that the industry at stake is currently developing, whose understanding appears crucial in order to better understand the purely legal arguments that will be pointed out below.

3.4 The industry's attempt to implement blockchain-based tools and the blockchain 'paradox'

As anticipated, the unique features of DLT technologies have led a wide range of companies to develop blockchain-based solutions for the digitalization of processes and documents related to trade finance, insurance or transportation and logistics, among others.

The following figure describes the current state of the art in the field covered by this research project:

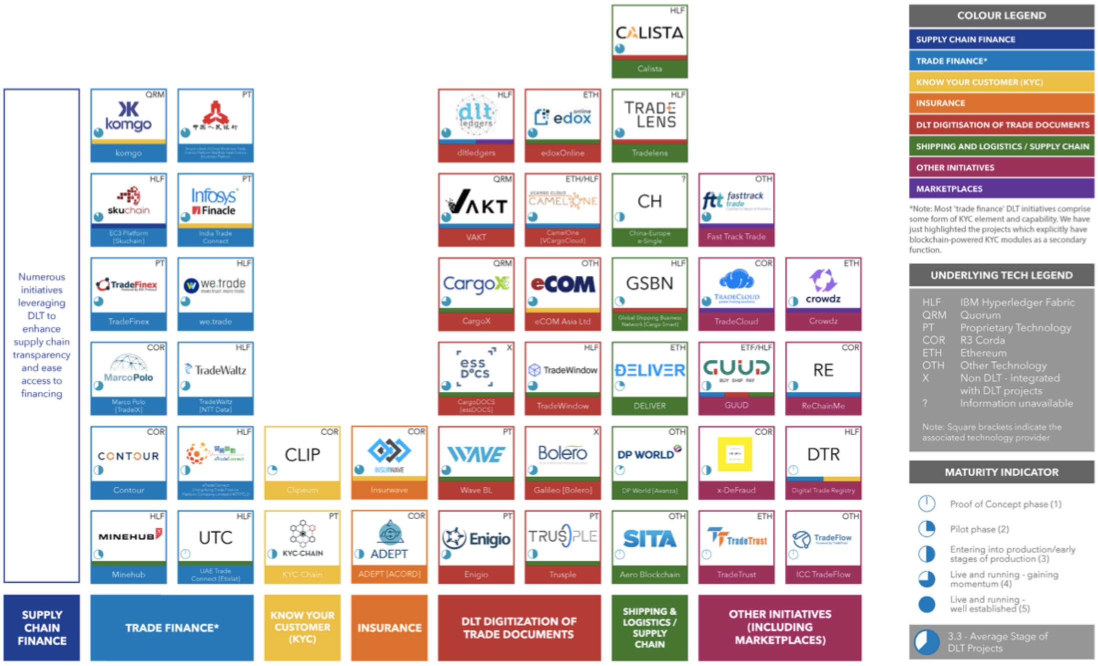

Figure 10. (Source: TRADE FINANCE GLOBAL and WORLD TRADE ORGANIZATION, *Blockchain and DLT in Trade: where do we stand?*, November 2020, pp. 12-13).

In this context, recent analysis based on shipowners' websites shows that all leaders of this specific market have shown great interest in the development and use of blockchain-based tools[147].

Here, APM-Maersk can be considered a pioneer, after launching its platform '*TradeLens*' in joint-venture with the hi-tech colossus IBM in 2017. The project has been subsequently participated by several other players of the market[148] with the general aim of promoting information sharing and collaboration across different supply chains and, therefore, reducing the above-described typical issues of international trade.

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[147] See WAGNER N., WISNICKI B., *Application of blockchain technology in Maritime Logistics*, in *DIEM: Dubrovnik International Economic Meeting*, 2019, 4 (1), p. 155. According to such a research "*the first eleven shipowners are engaged in such projects*", in a context where "*Shipowners active in the blockchain projects, in terms of tonnage, represent as much as 84% of the world container fleet*".

[148] See *Maersk's Blockchain Solution: Ready, Set, Go!*, in *Maritime Executive*, August 9, 2018, available at https://www.maritime-executive.com/article/maersk-s-blockchain-solution-ready-set-go.

According to TradeLens website[149], the project started with the following objectives:

a) bringing together all parties in the supply chain (such as traders, freight forwarders, ocean carriers, customs etc.) onto a secure data-sharing and collaboration platform;

b) ensuring through digitalization and automation that all documents and data are secured and auditable inside the blockchain environment, fostering collaboration and trust among participants;

c) encompassing shipping milestones, cargo details, trade documents, customs filings, sensor readings and more, through a seamless and secure sharing of real-time information across all the 'nodes' involved;

d) laying the foundation for the improvement of an '*applications programming interface*' ('API') marketplace which would allow third parties to design, build and deploy applications on the TradeLens platform.

At the current stage of its maturity, TradeLens has been developing applications that leverage its blockchain platform and are sold as '*Software as a Service*' offerings to an ecosystem of over 200 members. Indeed, the platform has currently received support from two-thirds of container shipping lines globally, over 80 terminals and ports, 17 customs authorities, dozens of inland providers, many corporates and banks, and several leading global and regional freight forwarders live on the platform[150].

The two products on the market today are '*Tradelens Core*' (*i.e.* an application aimed at providing users with an end-to-end insight on the status of a shipment

149 https://www.tradelens.com/about.

150 See TRADE FINANCE GLOBAL AND WORLD TRADE ORGANIZATION, *Blockchain and DLT in Trade*, cit., p. 44.

and granting efficiency throughout the shipment process in the light of the simultaneously presence of the different stakeholders involved) and '*TradeLens electronic Bills of Lading*' (*i.e.* a paperless instrument to create a standard, industry-supported, end-to-end digital solution that provides shippers, cargo owners and freight-forwarders a streamlined and secure process for the issue, transfer and surrender of original bills of lading.)

Unfortunately, 'enthusiasts' of blockchain's anarchy and equality will be disappointed by such a project.

TradeLens, indeed, is far from a 'pure' permission-less and decentralised blockchain, but has rather been structured in a permissioned ledger (running on Hyperledger Fabric, a specific blockchain developed by IBM) and aimed at providing several functional areas of the supply chain[151] with real time information concerning any moving cargo in Maersk's fleet[152], in so barring any direct intervention by anyone other than the owner of the platform, as the following figure describes:

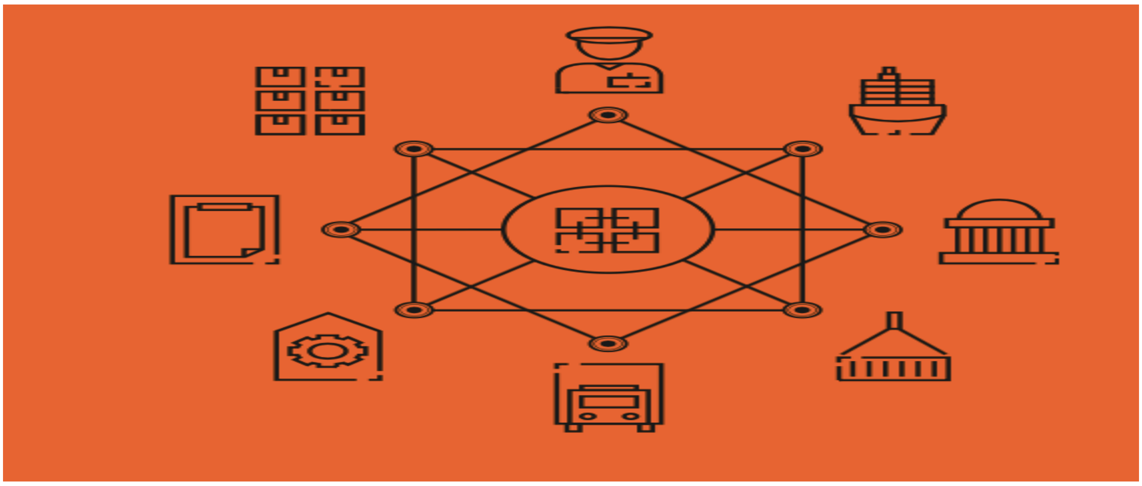

Figure 11. (Source: *TradeLens* website: https://www.tradelens.com/).

[151] E.g. beneficial cargo owners, inland transport operators, customs/government authorities, ports and terminals, ocean carriers, financial service providers, software developers.

[152] See again https://www.tradelens.com./.

This is probably why TradeLens raised concerns among competitors, who focused on the lack of neutrality of this kind of distributed network.

Therefore, in 2018 the remaining top-players of the container market (among whom, CMA CGM, COSCO Shipping Lines, Evergreen Marine, Yang Ming and PSA International)[153] established an alternative consortium (the already mentioned '*Global Shipping Business Network*') with the aim of introducing innovation and digital transformation to the supply chain and of exploring ways to improve global trade through enhanced collaboration among shippers, banks, terminal operators and ocean carriers, through – *inter alia* – a common trusted network which would not be owned by one single shipowner[154].

The pilot project, called '*Cargo Smart*', is still on-going, apparently as a solution to improve an efficient goods shipping documentation[155].

Finally, it has to be mentioned the '*Global Shared Container Platoform*' developed by BlockShipping with the support and partnership the Danish Maritime Fund[156].

BlockShipping's project generally aims at integrating 'Logistics 4.0' innovations (blockchain technology, cloud services, the Internet-of-Things) to enable a better utilization of containers through an efficient sharing of information between carriers. Here, the main instruments to be developed by BlockShipping seem to be the following:

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[153] Participants include carriers (CMA CGM, COSCO Shipping Lines, Evergreen Marine, OOCL, and Yang Ming); terminal operators (DP World, Hutchison Ports, PSA International, and Shanghai International Port); and a software solutions provider (CargoSmart).

[154] See WAGNER N., WISNICKI B., *Application of blockchain technology in Maritime Logistics*, cit., pp. 159-160.

[155] See www.cargosmart.ai/en/solutions/global-shipping-business-network/. According to the last WTO report '*as the GSBN Joint Venture formation is currently undergoing legal and regulatory approval, they are unable to disclose further information such as their revenue model or plans for future product deployments*', see TRADE FINANCE GLOBAL AND WORLD TRADE ORGANIZATION, *Blockchain and DLT in Trade*, cit., p. 43.

[156] See https://blockshipping.net/.

a) an '*AI-Import Dwell Time Prediction*', enabling users to predict when an imported container will be picked up from the terminal by applying artificial intelligence, which may result in a reduction of unnecessary container handling equipment utilization, gaining immediate efficiency improvements;

b) an '*AI-Terminal Truck Exchange*', using real-time information to create a match between import and export moves both at the terminal and the hinterland;

c) an '*AI-Container Flow Optimizer*', which aims at helping the container inventory management through an analysis of the existing data and the subsequent application of the artificial intelligence to predict when a container will be returned empty from an importer. According to its developers, such a program would determine an improvement of the forecasting ability for the flow of containers and, therefore, a saving of valuable resources;

d) a '*Blockchain Container Asset Register*', which declares itself to be the first blockchain-based container register of the world. Through the tokenisation of containers, the project aims at providing operators with undisputable titles of proof-of-ownership and, therefore, at '*improving significantly*' processes such as buying, selling and leasing of containers world-wide.

Such cases clearly highlight the huge interest that maritime industry is showing to blockchain technology.

Despite the magnitude of the potential benefits that may derive from its massive implementation, blockchain adoption by the logistics and shipping industry is nevertheless developing slower than one might expect.

Surprisingly, the definitive adoption of blockchain-based networks in the sector has been impeded so far by the very same obstacles relating to coordination and trust that the this technology itself would help the industry to overcome, such as (i) the highly fragmented value chain of multiple unrelated parties, which makes the industry well-suited for blockchain application but, at the same time, hinders the adoption of a common blockchain standard; (ii) the regulatory complexity due to the fact that logistics companies typically operate in multiple countries and jurisdictions with varying, and often complex, regulatory requirements; (iii) the lack of trust among the players of such and high competitive industry, where companies have traditionally relied on longstanding relationships with other value chain participants (including intermediaries and brokers) and, therefore, seem to be unwilling to share information outside of these longstanding relationships in favour of blockchain 'disintermediate' solutions.

That is, in essence, the declination of blockchain 'paradox'[157] in the logistics and shipping industry.

The following sections will be focused on the issue of whether instruments of uniform law and regulatory measures can be a possible instrument to solve it, at least partially.

[157] SCHMAHL A., MOHOTTALA S., BURCHARDI K., EGLOFF C., GOVERS J., CHAN T., GIAKOUMELOS M., *Resolving the Blockchain Paradox in Transportation and Logistics*, a paper by *Boston Consulting Group*, January 2019, available at https://www.bcg.com/publications/2019/resolving-blockchain-paradox-transportation-logistics.

'*As Max Weber highlighted, politics*
'is the slow boring of hard boards'.
Yet the absence of specific regulation concerning a technology
… does not mean that such system operates outside the law.'

(OSTER J., *Code is code and law is law*, 2021)

4. *LEX CRYPTOGRAPHICA* AS A *LEX MERCATORIA* 4.0?

SUMMARY: 4.1 The role of private autonomy in the development of international trade and origin of '*lex mercatoria*' – 4.2 The role of supra-national entities for the development of the '*new lex mercatoria*' – 4.3 Are blockchain technology and its codes mature enough to be considered as a new *lex mercatoria*? – 4.4 A preliminary conclusion: blockchain technology as a tool to create a '*lex mercatoria 4.0*' which can lead to a large-scale deployment of digital ecosystems

4.1 The role of private autonomy in the development of international trade and origin of '*lex mercatoria*'

In the context of international trade, private autonomy has often been the 'engine' for the development of uniform, transnational frameworks aimed at regulating contractual relationships between operators.

In the classical sense[158], contracts are viewed '*as the law which parties make themselves to govern their relationship*'[159], enshrining the idea that contractual parties are free to contract as they see fit, subject only to the requirements of legality and public policy compliance.

Under private international law, such an engine has repeatedly allowed best maritime practice to gradually overcome national theories that considered internal law as a coherent, unitary, and complete framework of regulatory measures and, therefore, hierarchically placed over any other rule or principle[160]. In other words, the idea was that of a privately ordered system which is governed by norms generated by the participants of the market ('from the

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[158] ZWEIGERT K., KOTZ H., *An Introduction to Comparative Law*, Oxford, 1998, p. 324.

[159] HUTCHINSON A., MYBURGH F., *International commercial contracts: autonomy and regulation in a dynamic system of merchant* law, in HUTCHINSON A., MYBURGH F., *Research Handbook on International Commercial Contracts*, cit., p. 1.

[160] See STURLEY M., *The history of COGSA and the Hague Rules*, in *Journal of Maritime Law and Commerce*, 1991, 22 (1), p. 15.

bottom up'), rather than imposed by a central sovereign State ('from the top down')[161].

This type of private ordering has long characterised international trade, at least if one subscribes to the historical narrative of the '*lex mercatoria*'[162] as the development of substantive merchant norms to be applied by special merchant's courts, that allowed the rising of both new branches of law (such as banking and insurance law) and legal instruments (as well as bills of exchange and other customs governing merchant sales and the shipping of goods).

Despite the medieval *lex mercatoria* narrative often providing a somewhat romanticized historical account of commercial law norms usually located in Western Europe and dated to the period 1000/1500 a.D.[163], there is no doubt that the medieval socio-economic context developed a set of common rules emerging from trade customs[164] and privately ordered according to merchant norms by specialist courts where often merchants, rather than lawyers, were appointed as judges since they were believed to understand commercial

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[161] There is an extensive literature on private ordering, most of which is of a socio-legal nature. For an overview, see RICHMAN B.D., *Firms, Courts and Reputation Mechanisms: Towards a Positive Theory of Private Ordering*, in *Colu L Rev*, 2004, 104, p. 2328.

[162] BERMAN H.J., KAUFMANN C., *The law of international commercial transactions* (*Lex Mercatoria*), in *Harvard International Law Journal*, 1978, 19 (1), p. 221; DESJARDINS A., *Introduction historique à l'étude du doit commercial maritime*, Paris, 1890; KADENS E., *The Medieval Law Merchant: The Tyranny of a Construct*', in *Journal of Legal Analysis*, 2015, 7, p. 251; PIERGIOVANNI V., *From Lex Mercatoria to Commercial Law*, Berlin, 2005; SCHMITTHOFF C.M., *The New Sources of the Law of International Trade*, cit.; ZIMMERMANN R., *Roman Law, Contemporary Law, European Law: The Civilian Tradition Today*, Oxford, 2001, p. 174.

[163] '*The role of Italian merchants tends to receive special mention, since it this era the Italian trade customs were more sophisticated and developed than in other parts of Europe. Thus, we hear of Italian merchant customs governing bills of exchange, insurance, banking, insolvency, agency and suretyship spreading to other parts of Europe through the processes of regional and international trade between various European centers*', see HUTCHINSON A., MYBURGH F., *International commercial contracts*, cit., p. 4.

[164] For a general overview of the principles that popularized the theory of *lex mercatoria* in the twentieth century, see MITCHELL W., *An Essay on the Early History of the Law Merchant*, Cambridge, 1904 and BEWES W., *The Romance of the Law Merchant*, Mytholmroyd, 1923.

practice[165], with the final aim of increasing the sense of *trust* and *security* among the operators of international commerce.

It is interesting to note that both *trust* and *security* are two of the main features that are fuelling the success of blockchain technology as well as the hype showed in recent years towards its development.

Then, one may assume that the above described *lex cryptographica* will sooner or later replace *lex mercatoria*, enabling the development and the spread of new commercial practices and institutes of customary law, based on trust among operators.

In order to verify whether such an analogy could be considered true or, otherwise, it shall be classified as a mere suggestion, it seems necessary to carry out a more in-depth analysis of the context in which it occurred.

Before doing so, it is however opportune to acknowledge the modern evolution of the merchant law by briefly mentioning the theory of the so-called '*new lex mercatoria*'[166], which places itself in continuity with the idea that merchant customs drive the development of commercial law and its progressive and dynamic adjustment to the contemporary era.

4.2 The role of supra-national entities for the development of the '*new lex mercatoria*'

Moving to modern times, and especially to the first half of the 20th century, some uniform acts of international law were adopted in order to consolidate trade usage and, therefore, to establish a common legal framework concerning *inter alia* sale of goods, maritime affreightment or carriage of goods by sea (e.g.,

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[165] According to scholars, in this context lawyers handling commercial disputes were indeed considered to be '*more preoccupied with their duty to enforce forum law rather than rules of commerce*', see TRAKMAN L.E., *Le Law Merchant: The Evolution of Commercial Law*, London, 1983.

[166] BERGER K.P., *The Creeping Codification of the New Lex Mercatoria*, Alphen aan den Rijn, 2010.

the already mentioned United Nations Convention on Contracts for the International Sale of Goods of 1980[167], the Hague Rules of 1924[168], as amended in 1968 by the adoption of the Hague-Visby Rules[169], the Hamburg Rules of 1978[170], the Rotterdam Rules of 2009[171]). Once ratified by individual States and enforced [172], international Conventions required compliance by national legislators, in view of the special nature thereof as compared to rules under domestic law.

Admittedly, international regimes provided for by Conventions have often required further fine-tuning by and among maritime stakeholders. These sources are, indeed, too narrow in at least two different ways: on the one hand, in their geographic scope of application and, on the other hand, in their terms.

By way of an example, it has been recently observed that none of the existing regimes by its terms governs the entire contract for a typical door-to-door multimodal transaction – as the Hague and Visby Rules only apply on a tackle-to-tackle basis, while the Hamburg Rules only apply on a port-to-port basis[173].

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[167] On this specific point, see COETZEE J., *CISG and Incoterms: reviving the traditions of lex mercatoria*, in HUTCHINSON A., MYBURGH F., *Research Handbook on International Commercial Contracts*, cit., p. 159.

[168] Convention for the Unification of Certain Rules of Law Relating to Bills of Lading, 25 August 1924, 12 *L.N.T.S.* 155.

[169] Protocol to Amend the International Convention for the Unification of Certain Rules of Law Relating to Bills of Lading (Hague Rules), 23 February 1968, 1412 *U.N.T.S.* 146.

[170] United Nations Convention on the Carriage of Goods by the Sea, 31 March 1978, 1695 *U.N.T.S.* 3.

[171] United Nations Convention on Contracts for the International Carriage of Goods Wholly or Partly by the Sea, 11 December 2008, General Assembly Resolution 63/122, U.N. Doc. A/RES/63/122.

[172] This is not yet the case of the Rotterdam Rules, that are not yet in force as they are still far to meet the condition required for them to be effective (*i.e.* a ratification by twenty States). For an analysis of the Rotterdam Rules and their genesis see STURLEY M., *Can commercial law accommodate new technologies in international shipping?*, in SOYER B., TETTENBORN A. (eds.), *New Technologies, Artificial Intellingence and Shipping Law in the 21st Century*, cit., p. 22.

[173] See STURLEY M., *Can commercial law accommodate new technologies in international shipping?*, cit., p. 25.

This is the reason why, together with international Conventions, a decisive role for the creation of a uniform substantive maritime/merchant law has been played by other instruments developed, one more time, through private autonomy. Reference is made to the so-called 'model laws' as well as to other international commercial customs (*i.e.,* commercial usages and practices) that have been so widely accepted as to be considered as authoritative texts designed to consolidate best practice already achieved by operators involved in international shipping transactions[174].

As a consequence, a 'third legal order' arose, which is distinct and autonomous from both domestic law and the international law of Conventions.

This is the so-called 'international law of traders' or 'new' *lex mercatoria*, characterising various sectors of activities[175] (e.g., international sales, maritime transport or banking operations) and aimed at

a) standardising the regulation of relevant relationships between parties, with a specific focus on their rights and obligations;

b) providing equal treatment of homogeneous situations between stakeholders from different countries in the world;

c) facilitating the predictability of applicable solutions, with a subsequent increase of *trust* between the parties involved.

These aims have been pursued through the elaboration of standard forms and clauses (e.g., the most commonly used charter-party contracts[176]), now used worldwide, in a context which is partially removed from the travelling

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[174] SCHMITTHOFF C.M., *The New Sources of the Law of International Trade*, in CHENG C. (ed.), *Clive M. Schmitthoff's Select Essays on International Trade Law*, London 1988, p. 206.

[175] TETLEY W., *Mixed jurisdictions: common law vs. civil law (codified and uncodified)*, in *Lousiana Law Review*, 2000, 60 (3), p. 678.

[176] CARBONE S., CELLE P., LOPEZ DE GONZALO M., *Il diritto marittimo – Attraverso I casi e le causole contrattuali*, Torino, 2015, p. 41; WILSON J., *Carriage of goods by the Sea*, London, 2010, p. 47.

merchants of the *lex mercatoria*, but where trade customs and commercial practice developed during this era still characterise aspects of contemporary commercial law.

The above suggests a system devised (at least partially) from the 'bottom up' logic indicated above, because the development of the model law defined as the 'new' *lex mercatoria* is mainly refined by supra-national entities such as UNIDROIT[177], the United Nations Commission on International Trade (UNCITRAL) and the Organisation for the Harmonisation of Business Law in Africa (OHADA)[178].

Nevertheless, the dissemination of such instruments has led to an almost complete 'delocalisation' of any underlying contractual relationships[179], notwithstanding the respect of States' relevant principles of public order and of the overriding mandatory provisions of national legal order[180]. Indeed, since the Institutions mentioned above exist independently of any particular State and create rules which parties may choose of their own volition, there is a strong element of merchant ordering involved in both the processes of norm creation and the adoption thereof.

The result is a system of private law-making and private governance existing at supra-national level[181] and which, as in the medieval age, has been allowing

[177] KREBS T., *The UNIDROIT Principles of International Commercial Contracts*, in HUTCHINSON A., MYBURGH F., *Research Handbook on International Commercial Contracts*, cit., p. 132.

[178] BERGER K.P., *The Creeping Codification of the New Lex Mercatoria*, cit., p. 43.

[179] With specific reference to maritime law, see the case *Luke v. Lyde* [1759], E.R., 617, with Lord Mansfield's statement "*Maritime law is not the law of a particular county, but the general law of nations*".

[180] CARBONE S.M., *Autonomia privata e modelli contrattuali del commercio marittimo internazionale nei recenti sviluppi del diritto internazionale privato: un ritorno all'antico*, in *Il Diritto Marittimo*, 1995, p. 318; LA MATTINA A., *L'Arbitrato marittimo e i principi del commercio internazionale*, Milano, 2012, p. 212.

[181] BERGER K.P., *The Creeping Codification of the New Lex Mercatoria*, cit., p. 40.

the development of such a new *lex mercatoria*, reversing perspectives based on a sort of legal nationalism.

In this context, national rules have become a means of implementing and/or elaborating a series of existing, self-sufficient and complete sources of customary law[182]; accordingly, relevant maritime practices have gradually changed their legal effectiveness from mere commercial standards to general rules able to (i) bind all operators of the sector at stake, regardless of the national system in which they are supposed to apply and (ii) require an autonomous interpretation to be found in the case law of the various States where such practice has been applied, thereby determining an eradication of a pure national law perspective[183].

Furthermore, in some sectors of international trade (e.g., line transport), private autonomy has not been considered exclusively as a way of regulating economic operations as a whole but, rather, as an instrument allowing

[182] GOLDMAN, B., *The Applicable Law: General Principles of Law - the Lex Mercatoria*, in LEW J. (ed.), *Contemporary Problems in International Arbitration*, London, 1986, p. 114.

[183] In a notorious judgement, the US Supreme Court stated that "*it happens that, from the general practice of commercial nations in making the same general law the basis and groundwork of their respective maritime systems, the great mass of maritime law which is thus received by these nations in common, comes to be the common maritime law of the world … [then] the received maritime law may differ in different countries without affecting the general integrity of the system as a harmonious whole*" (see *The "Lottawanna"*, 88 US (1875), at 573). With reference to English case law, see *The "Tolten"* [1946] All. E.R. 79. In the light of these features, *inter alia*, international arbitrations have been identified as the "natural seat" to solve this kind of transnational and autonomous disputes, see DELEBECQUE P., *L'arbitrage maritime contemporain: le point de vue français*, in *Il Diritto Marittimo*, 2004, p. 436; HARRIS B., *Maritime Arbitrations*, in TACKABERRY J., MARRIOT A. (eds.), *Bernstein's Handbook of Arbitration and Dispute Resolution Practice*, London, 2005, p. 743.

contracting parties to extend the scope of specific rules under international Conventions[184] or to subject one party to a more burdensome liability regime[185].

Private autonomy has therefore been continuing to have concrete value of normative background underlying the parties' contractual relationships, especially in the logistics and maritime sector.

4.3 Are blockchain technology and its codes mature enough to be considered as a new *lex mercatoria*?

In the light of the considerations set out in the previous paragraphs, a sort of common ground between the conceptualisation the modern *lex mercatoria*[186] and the features that may lead to a diffusion of blockchain technology can be found, thereby emphasizing the similarity of needs and values at their basis, *i.e.* (i) a deep dissatisfaction of individuals towards national State regulations in a complex global world and (ii) the subsequent quest for a liberal and spontaneous order for the development of their (even commercial) relationships.

Even though the 'charm' of drawing comparisons between a former *lex mercatoria* '*ex charta*' and a new *lex mercatoria* '*ex machina*' (*i.e.* the above-mentioned

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[184] By way of example, that is the case of the so-called "*Paramount clauses*" set forth in bills of lading and their application also to charter parties. See CELLE P., *La Paramount Clause nell'evoluzione della normativa internazionale in materia di polizza di carico*, in *Il Diritto Marittimo*, 1988, p. 11; ALVAREZ RUBIO J.J., *Las clàusolas Paramount: autonomía de la voluntad y selección del derecho aplicable en el transporte marítimo internacional*, Madrid, 1997.

[185] BARIATTI S., *Quale modello normativo per un regime giuridico dei trasporti realmente uniforme?*, in *Il Diritto Marittimo*, 2001, p. 491; CARBONE S., *Contratto di trasporto marittimo di cose*, in CICU A., MESSINEO F., MENGONI L., SCHLESINGER P. (eds.), *Trattato di Diritto Civile e Commerciale*, Milano, 2010, p. 81; LA MATTINA A., *L'Arbitrato marittimo e i principi del commercio internazionale*, cit., p. 213.

[186] HAYEK F., *Law, Legislation and Liberty: A New Statement of the Liberal Principles of Justice and Political Economy – Vol. 1: Rules and Order*, London, 1998, p. 36.

lex cryptographica) may be a compelling task[187], a series of *caveats* must be sketched in order to avoid incorrect and, probably, over-simplistic parallels.

It has been stated that public and private blockchains may potentially be equated to a '*proper transnational law regime*', enabling not only the creation of decentralised currencies, self-executing digital contracts and intelligent assets that can be controlled over the internet, but also the development of new governance systems featuring a more democratic decision-making process through a decentralised network of computers, which operates in a self-executive manner, on the basis of an *ex ante* regulation of users' conduct[188].

Even in this context, a first important point must be made in order to draw a line between the any possible evolution of the described *lex mercatoria* and a possible implementation of the *lex cryptographica* in the transport and logistics industry.

Indeed, as illustrated before, the former has been developed by expert traders and operators; in other words, by people who were aware of the praxis, duties and privileges thereof within a 'real', operational world.

Alternatively, the latter is a pure technological ecosystem working through complex digital algorithms that may not be easily accessible and intelligible to stakeholders in order to create *ex ante* regulations for their commercial purposes and relationships[189].

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[187] Someone has already described *lex cryptographica* and the concept of '*code is law*' as a return to the ancient and medieval model of *jus commune* among merchants from different places ('*digital medievalism*'). See GROSSI P., *L'invenzione del diritto*, Roma - Bari, 2017.

[188] See PONCIBÒ C., *Blockchain and comparative law*, in CAPPIELLO B, CARULLO G. (eds.), *Blockchain*, *Law and Governance*, cit., p. 137, and, again, DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit., p. 173.

[189] According to UNECE's *White Paper on Blockchain in Trade Facilitation – Version 2*, cit. "*Maritime trading partners that decide to implement Blockchain technology today will find it difficult to access the needed expertise for implementing because there is a lack of Blockchain talent and educational programs to develop such talent. There are a growing number of Blockchain start-ups, including in the maritime trade sector but they primarily sell standard products/solutions and do not develop tailor-made applications*" (see p. 60).

From this perspective, a fundamental difference between the two systems immediately arises. Indeed, in a blockchain-based scenario, each actor in international commerce would need to rely not only on well-established sector-related praxis and on a well-known system of laws and customs, but rather, they would have to make a step forward and translate both will and actions into digital means.

In such a scenario, the craving for freedom from the 'rule of texts' and its costly intermediaries might deliver international commercial trade into the hands of nothing more than a … more complicated 'rule of code' subject to other 'intermediaries', such as computer programmers, who would then become a-technical 'legislators' of the blockchain 'microworld'[190], in a system where every single mistake in the translation into code of wills expressed by the parties may generate immutable consequences all along the chain[191].

This can be a first and not trivial obstacle against a widespread and trusted dissemination of blockchains in the logistics and shipping industry, thereby fostering stakeholders' reluctance towards a potential sliding of such self-regulatory technologies into a 'technocracy' that might prove difficult for them to handle.

This scenario appears to potentally hamper the unity of the global system it was originally intended to help, thereby complicating, rather than simplifying and easing, commercial relationships.

Besides, scholars have already doubted that computer codes can cope with the often complex issues that lie at the heart of commercial relationships, such as the interpretation of contracts and the assessment of unforeseen situation

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[190] LASSÈGUE J., *Some Historical and Philosophical Remarks on the Rule of Law in the Time of Automation*, in CAPPIELLO B, CARULLO G. (eds.), *Blockchain*, *Law and Governance*, cit., p. 59.

[191] "*If a rule has not been correctly implemented as a smart contract, the consequences on that error could prove difficult to reverse without resorting to an after the fact judicial proceeding*", see DE FILIPPI P., WRIGHT A., *Blockchain and the Law*, cit. p. 201.

that may arise during their performance[192]. Indeed, '*the inherent 'rigidity' of algorithms and computer science is at odds with the much more nuanced approach lawyers and businessman tend to apply*'[193], with a subsequent paradoxical need for further (possibly, two-fold) qualified intermediation to make the 'dream' of a speedier, seamless and costless logistic chain come true.

Finally, also in this respect it has to be considered that, even though the *lex cryptographica* has – in theory – the requirements to be conceptualized as a '*global law without a State*'[194], it shall not operate in a legal *vacuum* but, rather, in a world where (national and international) laws, policies and/or regulations apply and must be respected in order to execute and/or enforce the digital transactions performed in the digital ecosystem represented in a blockchain.

At the current state-of-the-art, this may generate potential paradoxical situations whereby (i) the activity performed through a blockchain could be legitimate in the territorial context of a given State, but illegal and sanctioned in another jurisdiction, or (ii) the enforcement of certain technical solutions could be impossible in the world 'outside the chain', especially in case of maritime trade processes that are regulated by several different local authorities (e.g., port authorities, customs, harbour's master etc.).

In other terms, blockchain technology itself can probably create proper self-sufficient 'microworlds', but these would be too 'small' to accommodate all the processes of the sector[195] without, sooner or later, having to face the real physical 'macroworld', its rules and institutions, where events are not always computably decidable or foreseeable.

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[192] WERBACHT K., CORNELL N., *Contracts ex Machina*, in *Duke Law Journal*, 2017, 67, p. 312.

[193] MUNARI F., *Blockchain and smart contracts in shipping and transport. A legal revolution is about to arrive?*, cit., p. 14.

[194] PONCIBÒ C., *Blockchain and comparative law*, cit., p. 145.

[195] LASSÈGUE J., *Some Historical and Philosophical Remarks on the Rule of Law in the Time of Automation*, cit., p. 70; PISANTI N., LONGO G., *Le equazioni della natura. Sapere*, London, 2012.

4.4 A preliminary conclusion: blockchain technology as a tool to create a '*lex mercatoria 4.0*' which can lead to a large-scale deployment of digital ecosystems

In the light of the considerations set out above, despite the suggestion generated by the similarities between blockchain's features and some of the exigences of international trade, it is difficult to think that technology and its codes could one day completely replace the established systems of law, either under a national or an international perspective.

Otherwise, and as per the context of *lex mercatoria*, law and legislation shall be the main tool through which blockchain may, in a way, definitely accommodate the real world.

If this holds true, then an interplay between instruments of party autonomy (such as contractual agreements translated in digital language) and law is not only advisable[196], but rather essential to make blockchain effective and, thereafter, to finally bridge the gap between the two emerging regulatory structures at stake (*i.e.*, law and technology), joining forces to set up a system of functional equivalence[197] between digital and material world.

The above-mentioned process of interaction or, better still, of cooperation between code and law should be carried out in a twofold manner.

Firstly, and in an *ex-ante* perspective, the technology exploitation requires uniform regulatory measures that, mediating between a soft and a hard approach, will take technology from its current state of 'infancy' to a mature

[196] PONCIBÒ C., *Blockchain and comparative law*, cit., p. 152; TWINING W., *Globalisation and legal theory*, London, 2000.

[197] ESTRELLA FARIA J.A., *Uniform law and functional equivalence: diverting paths or stops along the same road? Thoughts on a new international regime for transport documents*, in *Elon Law Review*, 2011, 2, p. 1.

stage, in which blockchains may properly exploit all their potentials for managing private and commercial transactions across borders.

Secondly, and in an *ex-post* perspective, a cooperation between intermediaries (e.g., programmers and lawyers) seems unavoidable, in order, on the one hand, to create 'digital' praxis and contracts coherent with parties' intentions and, on the other hand, to easily allow a reverse-engineering process from algorithms to natural language in order to protect and grant parties' rights and interests in case of issues or disputes[198].

Such an interaction may prove to be the only way to make blockchain a really trusted eco-system which will help the flourishment of a 'digital' *lex mercatoria*, thereby allowing blockchain technology to finally take off on a large-scale in the logistics and shipping industry, as well as elsewhere.

This is the reason why, as a preliminary conclusion of my analysis, I believe that *lex cryptographica* cannot be defined as a completely new *lex mercatoria* but, more exactly, as a tool to implement a '4.0 version' of the *lex mercatoria* itself, supporting a more efficient handling of commercial relationships and, in so doing, requiring an intensive renewal of current laws and praxis.

In order to achieve this goal, a first crucial step[199] would be to accept and regulate in a uniform way the main instruments that new technologies are offering to support established international trade practices

By way of an example, a starting point could be to finally provide uniform standards for the recognition of e-signatures in the international trade[200],

[198] MUNARI F., *Blockchain and smart contracts in shipping and transport. A legal revolution is about to arrive?* cit., p. 15.

[199] So far, '*only a limited number of jurisdictions (about sixty) have established their own laws and standards regarding electronic signatures and digital transactions, whereas for electronic transferable documents, only five jurisdictions (Abu Dhabi, Bahrain, Belize, Kiribati, and Singapore) have adopted legislation based on the UNCITRAL's Model Law on Electronic Transferable Records*'. See GANNE E., *Blockchain for trade*, cit., p. 423.

[200] *Ibid.*, p. 421.

allowing the deployment of a secure and accurate identification method for the signatory of a data message and to indicate the signatory's approval of the information contained therein. Indeed, it would guarantee the origin and integrity of the data message and hence play a key role in digital processes of international trade.

Likewise, it could be opportune to grant functional equivalence to documents that still play a critical role in shipping industry (e.g., bills of exchange, bills of lading, promissory notes, warehouse receipts etc.) and digital transactions concluded within the blockchain, with the aim of providing the latter with the same effectiveness as the former, which continue to be almost exclusively paper-based in part due to the lack of legal recognition of electronic transferable documents.

Finally, international community should solve some uncertainties that remain around liability issues linked to the use of blockchain.

Such issues are minimized in trade-related blockchain applications by the fact that – as illustrated in the previous section – many of the on-going blockchain projects are based on permissioned platforms whose participants are known and whose governing rules in terms of functioning of the platform, liability, and dispute resolution can be determined as part of the governance structure of the platform. However, this can create another problem as these various rulebooks may not be aligned, thereby contributing to a detrimental fragmentation of approaches that undermines trade digitalization on a global scale.

To fulfil the needs mentioned above, specific regulatory measures shall be provided in a multi-level perspective involving

a) domestic legislation. Here, in order to better utilise the potential of new technologies and minimise the related risks, governments might consider taking – at list in the initial phase of this process – a facultative approach to encourage pilot projects with a certain degree of restrictions. In this vein, for example, the '*sandbox program*' adopted by the UK for the development of innovative technological products in the financial sector[201] could be a good way to provide a relatively relaxed environment where authorised organisations can test their innovations to a limited range of consumers for a limited duration while ensuring that appropriate safeguards are in place;

b) trade agreements between States, that may include provisions concerning new technological tools and their possible implementation between operators of the industry[202];

c) international conventions and/or customary 'model' laws, whose rules and institutes shall be made to provide uniform blueprints of legislation that States may locally use as a base to develop their own legislation supporting digitalization of trade[203] and, therefore, to imbue blockchain technology with sufficient legal certainty to spark the revolution it is

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[201] See UK FINANCIAL CONDUCT AUTHORITY, *Regulatory Sandbox Lessons Learned Report*, London, 2017, available at https://www.fca.org.uk/publication/research-and-data/regulatory-sandbox-lessons-learned-report.pdf. On this topic, see also PU S., SIU LEE LAM J., *Blockchain adoptions in the maritime industry*, cit., p. 12.

[202] By way of an example, '*the Australia-Singapore Digital Economy Agreement and the Digital Economy Partnership Agreement between Singapore, Chile, and New Zealand include specific provisions on electronic transferable records whereby the parties endeavor to adopt or to "take into account, as appropriate," relevant model legislative texts developed and adopted by international bodies, such as the UNCITRAL Model Law on Electronic Transferable Records*', see GANNE E., *Blockchain for trade*, cit., p. 423, making reference respectively to article 2.3 of the Digital Economy Partnership Agreement between Singapore, Chile and New Zealand and Article 8.4 of the Australia-Singapore Digital Economy Agreement.

[203] The UNCITRAL has been spearheading work on e-signatures and electronic transferable records in an effort to align approaches across jurisdictions and promote national action. Indeed, its 2001 Model Law on Electronic Signatures pursued the aim of enabling and facilitating the use of electronic signatures by establishing criteria of technical reliability for the equivalence between electronic and hand-written signatures. Furthermore, on July 13, 2017, the UNCITRAL adopted the Model Law on Electronic Transferable Records, which enables the use of electronic transferable records and sets out the conditions that must be met if an electronic record is to be treated as a transferable document. See the UN Info. Serv. Press Release, available at the following link https://unis.unvienna.org/unis/en/pressrels/2017/unisl251.html.

aimed at and, thereafter, facilitate a productive disruption of the current shipping practice. In the light of the highly international nature of the logistics and shipping industry, this latter option seems to be the preferable one, as it would allow for a uniform development of the relevant institutions worldwide, thus avoiding the possibility that only certain players, States or groups of States would acquire unbalanced market positions through an excessively 'blockchain-friendly' regulatory system.

It is an ambitious goal, which might be considered still far away to be achieved as the current state-of-the-art of blockchain's implementation process clearly shows with respect to one of the most diffused products of the *lex mercatoria*, which still represents a ubiquitous and fundamental document in international trade, shipping and finance transactions.

Reference is made to bills of lading, on which a more in-depth analysis is worth to be carried out in the following and final section of this thesis.

‘*We are all burdened with an antiquated commercial law system that is no longer facilitating commerce the way that it should*’

(STURLEY M., *Can commercial law accommodate new technologies in international shipping?*, 2019)

5. ARE BILLS OF LADING READY TO BECOME "*BLOCKS OF LADING*"[204]?

SUMMARY: 5.1 The origins of bills of lading and some analogies with the challenges that blockchain technology is seeking to tackle – 5.2 The functions of the bills of lading and their dynamic development – 5.3 Common issues of contemporary e-bills of lading – 5.4 '*Back to the future*': blockchain-based e-bills of lading and the challenges yet to face by them

An analysis of the role and the evolution of bills of lading over the years is, on the one hand, a practical example of the solutions that blockchain technology is theoretically able to provide the shipping industry with and, on the other hand, an instrument witnessing all the difficulties for such a potential 'game changer' technology to take off in the logistics industry.

As one of the oldest documents in shipping, the bill of lading is one of the best examples of the dynamic merchant tradition illustrated in the previous section, since its form and functions have evolved organically over the time to meet the demands of the actors of international trade.

However, even in the so-called era of 'paperless trade', paper bills of lading continue to dominate, giving rise to serial disadvantages for both stakeholders and regulators.

As it will be illustrated in the forthcoming, for decades 'electronic' bills of lading ('e-bills of lading') have been proposed as a functional solution, but their

[204]'This definition has been used in HERD J., *Blocks of lading' Distributed Ledger Technology and the Disruption of Sea Carriage Regulation*, in *QUT Law Review*, 2019, 18 (2), p. 306.

implementation still faces several challenges linked to some difficulties for the legal concept of bill of lading to '*dematerialise*'[205].

In such an evolution process, the impact of the above-described '*lex mercatoria* 4.0' can be evaluated in order to understand whether blockchain-based e-bills of lading (or, as already defined by someone, '*blocks of lading*'[206]) can effectively be a tool for entering a new phase of the evolutionary process at stake.

5.1 The origins of bill of lading and some analogies with the challenges that blockchain technology is seeking to tackle

The first reason why approaching bills of lading is of particular attention in the context of the present analysis derives from the fact that the needs underpinning their historical and gradual implementation have much in common with the issues that blockchain technology seeks to tackle.

As anticipated, the historical narrative describing the development of the bills of lading in the context of the *lex mercatoria* tends to identify the needs underlying their adoption in the truthfulness, reliability, accountability and security of the information and data concerning cargoes often exchanged between operators who may not know one another.

These are *a fortiori* crucial features in the context of contracts relating to goods that must be carried from one country to another across a sea of maritime perils separating importer and shipper[207].

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[205] GOLDBY M., *Legislating to Facilitate the Use of Electronic Transferable Records: A Case Study*, in *UNCITRAL Colloquium on Electronic Commerce*, New York February 14-16, 2011, available at https://www.uncitral.org.

[206] See footnote no. 2014.

[207] HERD J., *'Blocks of lading' Distributed Ledger Technology and the Disruption of Sea Carriage Regulation*, cit., p. 307.

As highlighted above, there is therefore a similar *rationale* behind blockchain technology and the middle-aged ancestor of the bill of lading, an initial form of ledger implemented by the shipping industry and known as *cartolario*[208].

At the time, shippers, carriers and other maritime operators needed a true record of the goods received on board of a merchant vessel detailing '*their nature and quantity*'[209]. The task had to be performed by something or – better – someone, that all parties involved in the shipment deemed trustworthy. Hence, a clerkship was instated wherefore, under oath of fidelity and by way of entering records of the goods on a ledger, hard copies of the register itself could be handed over to persons entitled to demand the goods[210].

In order to grant such a need, these 'archaic' bills of lading gradually developed into '*documents issued by a carrier or its representative including the master, evidencing that certain goods have been received and loaded onto a nominated vessel in a given port, to be transported to another port and delivered against surrender of the document*'[211], quickly becoming '*one of the oldest and most international forms of contract under both the common law and the civil law*'[212].

This practice has been incorporated into modern law as the '*one being accomplished, the others to stand void*' rule[213], evolving over the centuries and requiring bills of lading to progressively fulfil other functions.

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208 MUNARI F., *Blockchain and smart contracts in shipping and transport. A legal revolution is about to arrive?* cit., p. 5.

209 For a more detailed resume of the history of bills of lading, see AIKENS R., LORD R., BOOLS M., *Bills of Lading*, London, 2015; BENNET B.P., *The History and Present Position of the Bill of Lading as a Document of Title to Goods*, Cambridge, 1914; BENSA E., *The Earl History of Bills of Lading: an Essay*, Genoa, 1925.

210 MUNARI F., *Bill of lading*, in BASEDOW J., RÜHL G., FERRARI F., DE MIGUEL ASENSIO P. (eds.), *European Encyclopedia of Private International Law*, cit., p. 193; DESJARDINS A., *Traité de Droit Commercial Maritime*, Paris, 1890; MCLAUGHLIN C.B., *The Evolution of Ocean Bill of Lading*, in *The Yale Law Journal*, 1926, p. 548; WILSON J., *Carriage of goods by the Sea*, cit.

211 MUNARI F., *Bill of lading*, cit., p. 195.

212 TETLEY W., *Maritime Cargo Claims*, in *International Shipping Publications*, 1988, p. 215.

213 DUNCAN C.S., *The Uniform Bill of Lading*, in *J Pol Econ*, 1917, 25, p. 670.

5.2 The functions of the bills of lading and their dynamic development

More specifically, throughout history bills of lading have kept three fundamental functions.

As anticipated, these documents were born as a receipt of goods shipped to be issued to all the interested parties of a shipment. The need for copies of the register initially arose informally, but already in the fourteenth century many communities had introduced regulatory statutory provisions requiring copies of the register to be furnished on demand[214].

Alongside the 'receipt' function of bills of lading, a second one began to emerge during the sixteenth and seventeenth centuries[215]. Indeed, as the volume of trade increased with more cargoes and shippers per vessel, it became difficult for carriers to enter into different charter-party with each shipper; thus, a new practice developed of issuing a bill of lading in addition to charter parties, as instruments referring each other.

Thus, the bills of lading quickly became also evidence of their underlying contracts of carriage.

Finally, when a further change in merchant practice came up, whereby goods were dispatched before the shipper had determined their recipient at the port of destination, the need of documents that indicated entitlement to the goods arose.

As a consequence, the third function of the bill of lading developed, which imported transferability into such a document as evidence of entitlement to the goods. This soon allowed even the practice of trading goods while at sea (selling

[214] MCLAUGHLIN C.B., *The evolution of the Ocean Bill of Lading*, cit.
[215] DUNCAN C.S., *The Uniform Bill of Lading*, cit., p. 679.

goods afloat) through the endorsement and delivery of the bill of lading as a document of title representing symbolic possession of the goods.

The three functions of the bills of lading originated in merchants' practices and were subsequently endorsed by legislation[216] or judicial decisions.

Indeed, while domestic codifications elaborated the existing practices, these were arguably hindered the uniform international character of *lex mercatoria*, allowing a degree of uniformity in the international usage of the bill of lading and, at the same time, a certain dynamicity of such an instrument of international trade[217].

This feature holds relevance even as to its future evolution in the digital age[218].

5.3 Common issues of contemporary bills of lading

From its origins onwards, the evolution of the bills of lading in maritime trade transactions has been tied to paper-based documents, that are seen nowadays as a hindrance to fast pace and volume of trade.

Even though e-bills of lading have existed alongside paper bills of lading for decades as a tool for providing a more efficient transmission of these

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[216] E.g., the preamble to the British Bills of Lading Act of 1855 explicitly acknowledged the '*customs of merchants*'.

[217] By way of an example of this latter feature of bills of lading, the creation of the so-called 'Himalaya clauses' can be referred to. This originated as a contractual provision preventing cargo interests form circumventing the contractual defences which carriers may have (generally under the Hague-Visby Rules) by means of an action in tort against the carriers' servants, agents and independent contractors. Indeed, to avoid such a claim the clause extended to these latter parties the same protection that is afforded to the carrier under the contract of carriage. Developed as a contractual praxis, this clause was devised in the case law and, nowadays, it remains in common use in transportation documents. See YING C.A., *The Himalaya Clause Revisited*, in *Malaya L Rev*, 1980, 22, p. 212.

[218] NAIDOO L., *From the book of lading to blockchain bills of lading: dynamic merchant tradition and private ordering,* in HUTCHINSON A., MYBURGH F., *Research Handbook on International Commercial Contracts*, cit..

documents through the contractual network, they have essentially failed to replace their paper counterpart.

In the context illustrated above, indeed, the need to use these documents consistently with their function of documents of title must be handled with the utmost care[219], principally due to the fact that a bill of lading must be, first of all, 'transferable' between the parties involved in the shipment[220].

Before looking more closely into the main issues arising out of a possible wide-spread use of electronic bills of lading in the practice, a preliminary question has to be faced, this being why is such a modernisation (*i.e.* the implementation of e-bills of lading) so strongly looked at by the stakeholders?

First of all, and not astonishing, it is a matter of cutting costs.

For centuries, paper-based contracts have governed the relationship between shippers (or those who succeed to their rights) and carriers (or those who perform a carriers' work, as agents or sub-contractors). Although still relatively expensive, it has been estimated that paperwork makes up between 5 to 10% of the overall shipment costs[221].

Besides, paper documents may well determine further uncertainties and economic losses. A few examples can help to understand this argument.

First. In the current scenario, goods are often sold afloat and, in the light of the increasing speed of shipments, a paper bill of lading may sometimes reach the final buyer after the vessel has already arrived at the port of discharge. In such cases, the carrier may have to place the goods in storage, with subsequent

[219] LIVERMORE J., EUARJAI K., *Electronic Bills of Lading and Functional Equivalence*, in *Jorunal of Information Law and Technology*, 1998, 2, p. 1.

[220] WILSON J., *Carriage of goods by the Sea*, cit., p. 131, citing *Kum v. Wah Tat Bank* [1971] AC 439, 446.

[221] PANOS A., KAPNISSIS G., LELIGOU H.C., *Blockchain and DLTs in the Maritime Industry: Potential and Barriers*, in *European Journal of Electrical Engineering and Computer Science*, 2020, 4 (5), p. 1; STURLEY M., *Can commercial law accommodate new technologies in international shipping?*, cit., p. 23.

demurrage costs and other potential economic losses for the importer due to fluctuations in market value of the goods.

Second. The practice of delivering goods against letter of indemnity, arisen with the purpose to solve that very issue, is in any case a risky endeavour as the carrier may find himself '*liable to the rightful holder of the bill and … for breach of contract of carriage*'[222].

Third. Paper documents are generally more prone to instances of fraud or to be used as a sham, giving '*appearance of creating between the parties legal rights and obligations different from the actual legal rights and obligations that the parties had intended to create*'[223].

All these practical issues have generated concerns among the stakeholders in the industry, who have therefore sought to dematerialise paper bills of lading through digital means[224].

Although, and as anticipated, any attempt at digitally replicating bills of lading has yet been quite unsuccessful[225].

While this may, in part and paradoxically, be attributed to a 'parallel' reluctance of the shipping industry to leave widespread and well-known models and practices, two further issues have slowed down the deployment of e-bills of lading in the last decades.

The first one has been the lack of a suitable technology to replicate all the above-described functions of bills of lading in electronic medium. Indeed,

[222] GOLDBY M., *Legislating to Facilitate the Use of Electronic Transferable Records*, cit., p. 2.

[223] ONG N., *Blockchain Bills of Lading and the UNCITRAL Model Law on Electronic Transferable Records*, in *JBL*, 2020, p. 202.

[224] By way of example, that has been the case of (i) the so-called SEADOCS semi-automated system; (ii) CMI Rules for Electronic Bills of Lading of 1990; (iii) the Bolero System of 1994. On this topic see BURY D., *Electronic Bills of Lading: A Never-Ending Story?*, cit.; DUBOVEC M., *The problems and possibilities for using electronic bills of lading as collateral*, in *Arizona Journal of International and Competition Law*, 2005, p. 437.

[225] BURY D., *Electronic Bills of Lading: A Never-Ending Story?*, cit..

technologies that rely on central registries that operate according to a closed platform do not allow a wide participation by all the parties that may be involved in a shipment[226].

At the same time, legal concepts as 'possession' and 'enforcement' are struggling to find an equivalent meaning in an electronic environment[227].

The second issue has been the outdatedness of the legal framework governing such instruments and other negotiable documents of title[228].

International shipments are subject to a mosaic of legal regimes, established under international conventions, domestic statutes, doctrines and customary trade practice. At least in respect of electronic records to replace documents such as the bill of lading, commercial law is not facilitating commerce as it should, being in substance inadequate to deal with new technologies.

In a nutshell, it is possible to highlight that:

a) none of the existing international Conventions adequately addresses electronic replacements of traditional paperwork and neither the Hague Rules, nor the Hague-Visby Rules or the Hamburg Rules address the issue of dealing with electronic commerce, whereas the Rotterdam Rules – which might provide a possible legal framework for electronic bills of lading – are not in force (and it seems unlikely that they ever will be[229]);

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[226] STURLEY M., *Can commercial law accommodate new technologies in international shipping?*, cit., p. 26.

[227] GOLDBY M., *Legislating to Facilitate the Use of Electronic Transferable Records*, cit.

[228] HERD J., *'Blocks of lading' Distributed Ledger Technology and the Disruption of Sea Carriage Regulation*, cit., p. 308; LIVERMORE J., EUARJAI K., *Electronic Bills of Lading and Functional Equivalence*, cit., p. 3.

[229] Indeed, they require at least 20 States to ratify or otherwise adopt the Convention, whereas only four have done so to date. See NAIDOO L., *From the book of lading to blockchain bills of lading*, cit., p. 233.

b) in some countries, domestic statutes provide formal recognition for electronic records replacing paper-based documents. However, such recognition does not suffice as a legal basis for a real *international* trade[230];

c) furthermore, and under a practical perspective, many of the attempts so far developed to dematerialise bills of lading have relied on a central verified registry[231], which (i) fails to match up with the multiplicity of involved parties and to grant the 'uniqueness' of a transferable document of title as is a bill of lading, whereas the electronic bills of lading merely duplicated and re-printed the original, without ultimately granting that there would only be one copy of the bill in circulation[232]; (ii) raises further issues of fraud, corruption, destruction and hacking into the central registry; (iii) meets the reluctancy of operators to submit to a central, and mostly unknown, authority.

Such legal uncertainty has substantially entailed the fact that stakeholders failed to fully support the implementation of electronic bills of lading in maritime trade, in view of their concern related to the exchange of documents that would not be enforceable under most of the involved jurisdictions.

Indeed, without consistent rules that uniformly apply to every stage in the performance of a contract, commercial parties are lacking both the certainty and predictability of an efficient development of new technologies.

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[230] STURLEY M., *Can commercial law accommodate new technologies in international shipping?*, cit., p. 26.

[231] This is the case of the above-mentioned Bolero system, which was launched in 1999 and is governed by the Bolero Rule book; similarly, essDOCS is governed by the Databridge Services & User Agreement (DSUA) and e-Title is governed by the multi-lateral contract called the Electronic Title User Agreement. See STARR L., TAN J., *Electronic Bills of Lading – An Update Part I*, in *UK P&I*, March 26, 2020; BURY D., *Electronic Bills of Lading*, cit., p. 218.

[232] WHALEY D.J., MCJOHN S.M., *Problems and Materials on the Sale and Lease of Goods*, Alphen aan den Rijn, 2019, p. 501.

5.4 ‘*Back to the future*’: blockchain-based e-bills of lading and the challenges yet to face

Once briefly analysed the previous attempts at developing and using e-bills of lading in the logistics and shipping industry, blockchain technology seems to have potentials to overcome at least the practical issues mentioned above, thereby fulfilling all the traditional functions of the bill of lading without hampering its mandatory ‘uniqueness’.

Indeed, dematerialisation of a bill of lading requires to reply two essential features of the document: its singularity (*i.e.*, the ‘guarantee’ of its uniqueness) and the granting of exclusive control over the goods[233] (the document is a symbolic ‘key to the warehouse’).

In the light of the process of tokenization and the concurrent massive use of cryptography, the exchange of e-bills of lading in a blockchain-based network characterised by encrypted transactions may (i) enable the owner of the bill of lading to be identified from the tokenized document itself: e.g., a cargo owner would be able to endorse e-bills of lading with its own digital signature and include the public key of the next owner in the transaction, so that the transfer of the document of title in the blockchain will be recorded in chronological order and used to trace the ownership history by verifying signatures; (ii) assure the uniqueness of a bill of lading as any other token inserted and exchanged in the chain[234].

These are the most interesting features emerging from the main blockchain-based pilot projects developed to date in the maritime sector, namely the above-mentioned ‘*TradeLens electronic Bills of Lading*’, running on a permissioned blockchain as IBM’s Hyperledger Fabric, and the simultaneous project to create

[233] GOLDBY M., *Legislating to Facilitate the Use of Electronic Transferable Records*, cit.
[234] ONG N., *Blockchain Bills of Lading and the UNCITRAL Model Law*, cit., p. 206.

'*smart bills of lading*', which has been carrying out by CargoX on a public blockchain with the aim of '*connecting all relevant parties that are regularly involved in the transport process in a balanced system based on trust and interaction*'[235].

Despite their potentials for a massive diffusion in the industry[236], even blockchain e-bills of lading are still subject to some disruptive effects that have not been completely dealt with by the stakeholders.

A. The 'technical' challenge

A first disruptive effect to be mentioned is the fragmentation of platforms which still characterises blockchain's environment in the logistics and shipping industry.

While the most significant feature of the shipping industry can be considered its relative uniformity compared with the others[237], stakeholders are currently developing their projects of blockchain-based e-bills of lading on different platforms not communicating in a consistent way.

[235] More specifically, the platform offers several types of smart bills of lading (such as negotiable bills of lading, straight bills of lading and sea waybill) and other documents (bills of materials, cargo damages reports, certificates of analysis, fumigation, inspection, claims notifications, container arrival notices, contracts, cover letters etc.). The smart bills of lading record any action on the blockchain together with a timestamp, offering a more secure and transparent way of handling cargo ownership transfers. See *Cargo X Business Overview and Technology Bluepaper*, available at https://cargox.io/CargoX-Business-Overview-Technology-Bluepaper.pdf, and MAREKNOVIC S., TIJAN E., AKSENTIJEVIC S., *Blockchain Technology Perspectives in Maritime Industry*, cit., p. 1416.

[236] A 2019 CargoX pilot who used blockchain to transfer a bill of lading between a Chinese exporter and a Peruvian importer was able to demonstrate these benefits. According to the International Transport Forum, the transfer of bills of lading using legacy systems can take up to ten days to third-party couriers and several document exchanges, plus any delays caused by misplaced or improperly processed documentation. In the CargoX case, these inefficiencies would have been in addition to the seven-week voyage of the shipment itself. Instead, the blockchain reduced the bill of lading transfer from weeks to minutes while making the process more secure. See, INTERNATIONAL TRANSPORT FORUM, *Forging Links*, cit., p. 28 and CargoX website https://cargox.io/welcome.

[237] VAN HOOYDONK E., *Towards a Worldwide Restatement of the General Principles of Maritime Law*, in *Journal of International Maritime Law*, 2014, 20, p. 170; TETLEY W., *The General Maritime Law – The Lex Maritima*, in *Syracuse J. Int'l L. & Com.*, 1996, p. 469.

Therefore, the projects that initiated the transfer of e-bills of lading through blockchains are, so far, different and incompatible each other: for instance, Hyperledger Fabric's TradeLens will not be able to technically 'talk' to CargoX, which relies upon the Ethereum blockchain. At the same time the GSBN project run by CargoSmart, although also built upon Hyperledger Fabric, will not share data with TradeLens.

As a consequence, the current, relatively unified custom and usage governing the flow of bills of lading may be significantly undermined by these technical inconsistencies.

Moreover, and extending the focus outside the small scope of blockchain-based e-bills of lading, it is possible to point out that blockchain-based systems that have been developed for other industries (such as Everledger for supply chains and R3 Corda for banks) are, again, characterised by a non-communicability issue *vis-à-vis* e-bills of lading, notwithstanding the fact that an interoperability between these systems would be in this context even more essential to grant a smooth transfer of bills of lading among the actors of the international trade.

Last but not least, blockchain bills of lading platforms also need to be compatible with government systems, such as customs authorities, in order to grant a smooth progress of the processes for the import and export of goods.

Again, without interoperability, all these blockchain-based e-bills of lading platforms will be like 'digital islands' not able to communicate each other.

B. The 'regulatory' challenge

The second challenge for the deployment of blockchain bills of lading is, again, regulatory.

As in the case of its predecessors, neither blockchain-based bills of lading can be used as document of title without the support of legal structures allowing such a function to be pursued.

Otherwise, the technical development of such a solution within the context of shipping shall go hand in hand with a legal framework specifically designed to embrace its implementation within operators' relevant practice.

But how so?

As anticipated above, the development of an international regulatory approach appears to be conducive to the granting of legal and functional equivalence between DLT-based bills of lading and physical documents of carriage, in order to ensure that the former will be recognized in the exact same way as the latter.

This is, indeed, the approach so far adopted at a twofold level, corresponding to both the legal formants of the abovementioned *lex mercatoria*, *i.e.* (i) international Conventions and (ii) acts of customary uniform (and soft) law.

When dealing with the first of these categories, one should take into account Rotterdam Rules' attempt to facilitate electronic commerce within the shipping industry[238].

In this vein, chapter 3 of the Rotterdam Rules is specifically dedicated to *electronic transport records* and

a) explicitly authorizes anything that can be done with a paper transport document to be done with an electronic transport record, proving involved parties agreement (Article 8(a));

[238] STURLEY M., *Can commercial law accommodate new technologies in international shipping?*, cit., p. 29, where Rotterdam Rules are defined as '*much more than just a liability convention*'.

b) specifies that in this case all the relevant actions performed with an electronic transport record (*i.e.*, issuance, possession or transfer) have the same effect as the corresponding actions with a paper transport document (Article 8(b));

c) provides for procedures governing the use of electronic transport records (Article 9);

d) enables paper transport documents and electronic transport records to replace one another (Article 10).

Although, the lack of interest that has so far characterised some States' approach to the Rotterdam Rules seems to constitute the first real brake preventing the industry from '*mov[ing] past the slavish adherence to paper documents that has created so many problems*'[239].

Nevertheless, if the impact of this Convention has not caught the interest of governments[240] (with the effect that the Rotterdam Rules has not yet, as anticipated, come into force[241]), a similar approach has recently been followed by UNCITRAL with regards to soft law.

Reference is made to UNCITRAL's draft of '*Model Law on Electronic Transferable Records*' ('MLETR')[242] which endeavours to guide legislative development so as to averse blockchain and DLT regulatory disruption.

As a starting point, the MLETR correctly recognises that (i) '*uncertainties regarding the legal value of electronic transferable records constitute an obstacle to international*

[239] STURLEY M., *Can commercial law accommodate new technologies in international shipping?*, cit., p. 35.

[240] Again, STURLEY M., *Can commercial law accommodate new technologies in international shipping?*, cit., p. 35.

[241] See footnote n. 228.

[242] https://uncitral.un.org/en/texts/ecommerce/modellaw/electronic_transferable_records.

trade' and, therefore, (ii) an international '*harmonization and unification of the law*' is required.

In this vein, UNCITRAL's regulatory approach pursues two guiding principles, *i.e.,* technological neutrality[243] and, again, functional equivalence[244], aiming at establishing equal treatment of transferable electronic records and paper documents. This kind of approach appears to be balanced enough to embrace the needs of a phenomenon (*i.e.*, technical innovation) that is developing at a faster pace than that required by domestic and international policymakers to understand and regulate it.

In the light of the above, it is possible to conclude agreeing with those scholars who maintain that '*if such regulation becomes widely adopted, bills of lading will eventually be rendered, first, a part of history and, secondly, a legal test by which to judge other technologies in the shipping industry*'[245].

This is probably how a proper and uniform 'law of blockchain' should be developed and the use of the technology should be encouraged, either in the maritime shipping context or across sectors wherein blockchain is currently expected to become a game-changer.

[243] "*Law should not require a specific technology system to be used. The benefit of regulating new technology this way is that the rules will remain relevant despite further technological innovation*", see HERD J., *'Blocks of lading' Distributed Ledger Technology and the Disruption of Sea Carriage Regulation*, cit., p. 315.

[244] See article 7 of the MLETR, according to which it "*shall not be denied legal effect, validity or enforceability on the sole ground that it is in electronic form*"

[245] See again HERD J., *'Blocks of lading' Distributed Ledger Technology and the Disruption of Sea Carriage Regulation*, cit., p. 315.

CONCLUSIONS

I have opened the present thesis with the provocative and tricky question regarding whether the development of blockchain technology in everyday life may still be referred to as the 'game-changer' it was originally (and enthusiastically) called[246] or, rather, whether it is more similar to William Shakespeare's "*much ado about nothing*".

I believe that all the above-illustrated considerations about the current state-of-the-art of blockchain deployment in the logistics and shipping sectors, together with the subsequent analysis of some of the most perceivable legal issues thereto related, can lead to some preliminary answers.

First of all, blockchain is – by design – an innovative tool, which holds the potential to overcome some of the operational issues characterising the sector at stake. Nevertheless, it cannot possibly be taken as a *panacea* for all challenges addressed by the stakeholders in their activity.

Bearing this in mind, and also considering costs – in terms of both energy and money – relating to a widespread use of blockchain technology, its development must act as a wake-up call to a traditional and conservative community in search of a functional tool able to satisfy operational needs, and certainly not as obsessive quest for the adoption a completely decentralised and distributed ecosystem in which pour out all the business processes of the industry.

[246] More recently, Elon Musk twitted that '*SpaceX is going to put a literal Dogecoin on the literal moon*' (@elonmusk on Twitter, April 1, 2021), paving the way to powerful narratives to promote new ways of governing outer space through distributed ledger technologies. On this point, see also DE FILIPPI P., LEITER A., *Blockchain in outer space*, in JALAL I., SHUKUR Z., BAKAR A., *Study on Public Blockchain Consensus Algorithms*, cit.

Otherwise, stakeholders shall carefully identify the specific activities in which they want to implement such an innovation and then pursue only those that cannot be better performed through using other kinds of technology[247].

Secondly, for blockchain technology to effectively meet needs of the shipping industry, a purely theoretical vision of this technology as a 'stand-alone ecosystem', which is completely self-sufficient and able to regulate itself through a series of codes and system settings (the so-called *lex cryptographica*, as defined above) should be relinquished. Indeed, the coexistence and interplay of law and technology should be encouraged and developed, as this may prove to be the only way for blockchain to reach its much-awaited 'maturity' phase and, therefore, solve some operational issues in several sectors of the industry.

In this context, international Conventions and acts of customary law could be, another time in the history of international trade law, the cornerstones not of a completely 'new' *lex mercatoria* but, rather, of a '4.0 version' of the current *lex mercatoria*, which may well greatly facilitate market needs. Indeed, it is plausible that, even in the near future, it will be the law's realm to decide, on the one hand, to what extent its own digitalization is permissible and, on the other hand, the limits on the use of new technologies, which shall be compatible with legal rules and general principles (such as fundamental rights, transparency, proportionality, separation of powers etc.)[248].

[247] "*Through 2018, 85 per cent of Blockchain-named projects would deliver business value without using a Blockchain*", see UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE (UNECE), *White Paper on Blockchain in Trade Facilitation – Version 2*, cit., p. 66.

[248] It has already been stated that '*Somewhat paradoxically, the vagueness of legal principles and open texture provisions that constitute such an impediment for the application of machine to the law … is to a certain extent necessary to render justice possible in individual cases. The question to what extent laws have to remain general, and to what extent they may be individualised and self-enforcing, is thus a question of the legality of specific legislative 'design choices' rather than a fundamental, binary question. Laws need to be codified not in their maximum or minimum complexity, but in their optimal complexity*'. See OSTER J., *Code is code and law is law*, cit., p.15.

In order to achieve such an ambitious goal, stakeholders and competent policymakers alike should adequately be catch-up with this new trend and strive to strike a balance between a cyber-paternalistic and a cyber-libertarian regulation[249] while still bearing in mind that '*Technology is now deeply intertwined with policy. We are building complex socio-technical systems at all levels of our society … Surviving the future depends in bridging technologists and policymakers together*'[250].

And with specific reference to the logistics and shipping industry, bridging the gap would mean that (i) stakeholders shall strive to deploy technological tools that can, at least, interact with each other and to establish uniform standards of experimentation and application of the new distributed ledgers; (ii) for their part, regulators shall set boundaries between law and technology, seeking an appropriate balance between fostering innovation of the blockchain technology and safeguarding the safety and security of the market participants, as well as the interests of the public as a whole.

On this latter point, it must be noted that, while a majority of jurisdictions are employing a wait-and-see approach, an advisable approach would be to encourage the study of pilot projects with a certain degree of restrictions, such as in the so called 'regulatory sandboxes', in order to effectively test the possible impacts of the technical innovations.

Once the possible practical applications (and related problems) have been studied more closely at a local level through these pilot projects, a uniform international regulatory system must be created in order to create, on the one hand, law institutes and best practices to be widely applied in the international scenario characterising the logistics and shipping industry, and to prevent, on the other hand, that only certain players and/or Countries would take over

[249] PONCIBÒ C., *Blockchain and comparative law*, in CAPPIELLO B, CARULLO G. (eds.), *Blockchain*, *Law and Governance*, cit., p. 137.

[250] SCHNEIER B., *We must bridge the gap between technology and policy making. Our future depends on it*, in *World Economic Forum*, 2019.

unbalanced market positions through an excessively 'blockchain-friendly' regulatory system, tailored-made on their specific exigences and not on those of the industry as a whole.

In the light of all the considerations set out above, it is possible to conclude that blockchain may well come up as '*much ado about nothing*'. Indeed, one could argue that although Bitcoin first appeared in 2008, twelve years later it is still not possible to note an effective and concrete booming of blockchain-based applications in our daily life.

Nevertheless, if programmers, policymakers and operators, as well as already established middlemen such as lawyers, cooperate and share skills in order to guarantee an effective interplay between law and technology at a global level, blockchain would definitely become the 'game-changer' thereby properly revolutionising the world we inhabit.

In this sense, the world of logistics and transport could once again pioneer this trend. As challenging as it can be, reasons seem to exist to make working on it worthwhile.

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