Tokenising Property

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ABSTRACT

The rise of NFTs have changed the blockchain landscape, allowing to tokenize and trade chain "real-world" off-chain assets and build claims on such assets. Such underlying assets can therefore be the object of transaction both on-chain and off-chain. Thanks to its technological design, the blockchain provide a solution for the double spending problems but only for on-chain transaction. Therefore, there is the possibility that incompatible contracts are concluded.

In an off-chain environment, incompatible contracts are analysed by Hansmann and Kraakmann who demonstrated that property rights *numerus clausus* is an evolutionary efficient way to address the problem of incompatible contracts.

This paper discusses how blockchain tokenisation disrupt this long-lasting state of things, showing how the technological design of the blockchain replicates many, but not all, the feature of property rights.

The analysis is based on a wide law & economics literature that has dealt with the topic that allows us to build an analytical framework to approach the issue. Thereafter, we provide real-life two examples that highlight how the blockchain commingles features of property rights and contract right, discussing the implications of this feature.

Keywords: property rights; incompatible contracts; tokenization; NFT

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1. Introduction

In the last years, the blockchain has undergone an extraordinary development. It is not anymore limited to cryptocurrency exchange: the possibility of tokenising non fungible asset has led to an expansion of the market which was unimaginable when Satoshi Nakamoto first published his "Bitcoin: A peer-to-peer electronic cash system" (2009), unanimously considered the whitepaper of the blockchain. A particularly lively segment of the blockchain market is now dedicated to the exchange of tokenised real-world asset and claims in real world-asset.

The widespread of this new technology has arisen some issues concerning the conclusion contradictory contracts in the blockchain and in the physical market. Two contracts are contradictory whenever they give rise to competing claims on the same asset, that could not coexist; a contradiction between contracts is not conceivable when the exchanged token is on-chain native and do not represent any value outside it, because DLT technology prevents any form of double spending. Therefore, the scope of the research will focus on tokens representing existing assets which can be exchanged off chain too. Normally, the problem arising from the conclusion of contradictory contracts is solved in the light of the distinction between property and contractual rights. Nevertheless, the blockchain does not necessarily respect the publicity mechanism that the parties must satisfy to transfer property rights. In this perspective, competing claims will be solved against blockchain users, thus limiting the diffusion of a potentially enhancing technology. The proposed solution, to recognize the blockchain as publicity mechanism for tokenized asset, is evaluated on the basis of the transaction costs theory. Is this enough to ensure efficiency of the property law system?

Actually, it does not seem so. The blockchain displays features that result in discrepancies between the law and the code. In particular, the automatic enforcement of smart contracts seems not only to be able to prevent any breach of contract, but also to create a *de facto* direct relationship with the asset. As a consequence, aligning the digital and legal effects of the transaction leads to an increase in transaction costs. In this sense, simply using the blockchain to transfer already existing rights does not seem to reach the efficiency goal. The paper tries to suggest some solutions. In particular, it discusses the possibility of broadening the flexibility that the parties enjoy in defining the content of their property right.

The paper unfolds as follows. Section 2 reviews the literature on the distinction between property and contractual rights. In particular, it is explained that property rights can be enforced also against subsequent transferee of the asset, while contracts right, due to their nature as *in personam* rights, cannot. As a consequence, legal systems have organized property rights in a closed number (*numerus clausus* principle) and has conditioned their in *rem* effects to the respect of a publicity regime. The choice has been justified also from an economical perspective. The paper focuses on the authors who have been defined "transactional", who conclude that the *numerus clausus* is desirable as it leads to a decrease in transaction costs and consequential increase in efficiency. Even if the *numerus clausus* can be explained also in other ways the transactional theories are particularly fitting, due to crypto-enthusiasts' claim that trading on chain would significantly reduce such costs.

Section 3 gives a brief insight of the technological background. After explaining what is the blockchain and its basics innerworkings, it focuses on smart contracts. In particular, their main feature is automatic execution to the terms that define the relationship between the parties. The

importance of the automatic execution in preventing the breach of the contract has led the crypto-enthusiast to rediscover the motto "the code is law" (Leissig, 2006): in this light, the protocol defines what the users can and cannot do on chain, validating and giving execution to users' transactions, providing that they respect a predefined set of conditions. The paper then focuses on the kind of rights that can be transferred through the blockchain. It is argued that when transferring on-chain tokens that represent property rights on real-world asset, the effects *in rem* will be conditioned to the respect of the publicity regime established by law.

Section 4 analyses blockchain potential as a legally recognized publicity mechanism on the basis of transaction costs. A review on the literature, which has focused mainly on the analysis of the blockchain in NIE (New Institutional Economics) framework will be followed by the qualitative analysis of the transaction costs that would bore the blockchain. It is possible to think that at least in some situation the blockchain could help in reducing transaction costs.

Section 5 shows how the blockchain disrupts the traditional distinction between contract and property right. Firstly, seamlessly with similar experiences attempted off chain, it allows to bind subsequent owners of the asset imposing the repetition of contracts terms. Actually, whenever a token is transferred through the blockchain, the terms of the exchange are already set in the smart contract that embeds the token. Moreover, thanks to the widespread of forms of smart management of the property, the automated enforcement of smart contracts is able to operate directly with the asset involved. Such functionalities allow to give automated execution to a contract right against subsequent transferee off-chain. In case of judiciary enforcement of a property right incompatible with the smart contract the factual relationship created by the smart contract, it will be necessary a reverse transaction, thus increasing the overall costs. Few hints are given on the viable options to solve this problem and exploit the full potential of DLT. In particular, two solutions are considered. The first, to align the code to the law; the second, to align the law to the code, giving more flexibility to existing property rights and, if necessary, recognizing the existence of new property rights.

Section 6 concludes.

2. The Legal Background

2.1. Contractual rights and property rights; the numerus clausus principle

Traditionally, when claims on resources are concerned, the Modern Western Legal Tradition distinguishes between property rights (*in rem*) and contractual claims (*in personam*). Property rights create consent to exert the power on the asset in two ways, benefitting from the asset in any fashion desired and excluding others from doing the same. The traditional representation, consisting in the overlapping between the thing and the right has been replaced by a relational view that describes the claim of the owner as linked with a corresponding duty that compels an undetermined number of people (all society members) not to interfere with the use of the good (Hohfeld, 1917); in case of infringement, it can be enforced *erga omnes.* If the owner transfers the asset any (partial) property right "run[s] with the asset" (Hansmann & Kraakman, 2002): which means that they "survive unaltered through all kinds of transactions and transformations dealing with other rights" on the same asset (Arruñada, 2003). This statement has two consequences. Firstly, in order to affect a property right the owner must give his consent, and the valid transfer of the ownership in the asset is conditioned to every property right owner's consent (Arruñada,

2003). Secondly, if such consent is lacking any transferee of the asset will be bounded by that property right, which remains unaffected by the trade (among others, Merril & Smith, 2000; Hansmann, Kraakmann, 2002; Arruñada, 2003)[3].

Contract rights differ from property rights, as they reflect a legally relevant relationship with a person. In particular, they express an obligation that the grantor is compelled to fulfil, and that can be enforced against him in case of default. At the same time, no other member of the society will be involved in the relationship: in case of subsequent trade, the asset will be transferred free from the burden (Hansmann & Kraakmann, 2002; Arruñada, 2003).

Another difference between property rights and contractual rights lies in the fact that while contractual rights are an open system, property rights are usually determined in a closed number (*numerus clausus*). According to this principle "property rights are limited in number (…) and in content" so that "private parties must choose from a predefined set of property rights of which the content is already pre-established, to a considerable degree" (Akkermans, 2017). As a result, the parties are constrained to choose the content of the property right respecting the requisites of more or less broad categories, depending on the choice of the law system. It is pretty seldom, anyway, that a standardized content is established. The *numerus clausus* principle derives from the refusal of the feudal system in France and Germany of XIX century: the affirmation of the exclusivity of control on resources as one of the most important social values, connected with the climb of the bourgeois in the social ladder, played a vital role. In this context, partial property rights were seen with suspicion: they impose long-lasting burden on property, weakening the value of the asset even after the transfer (Hansmann & Kraakmann, 2022; Akkerman 2008).

On the contrary, the parties enjoy absolute freedom in shaping contractual rights, which can be enforced just against the original grantor. As a consequence, if the parties wanted to create a "time-share" property right on chattels, so that its owner would enjoy the good only on Mondays (the example derives from Merril & Smith, 2000, 27 ss), this right could have only *in personam* effects. Due to the fact that such right is not comprehended in the categories of property determined by law, it would not be able to bind any subsequent transferee of the asset.

The implementation of the principle has been stricter in some countries than others; so, while in Germany it is always precluded new property rights non provided by statute, in France the *Cour of Cassation* can recognize new property rights (Akkerman, 2008)[4]. The demand for a certain degree of flexibility has anyway led to a decrease in the differences between contract law and property law. Relevantly, the attempt to bind subsequent transferee of the good to claims not recognized as property right can be seen in the famous «Projansky contract» (also known as the «Artist's contract»)[5]. The «Artist's contract» is born to safeguard the economic interest of the artist to enjoy the increase of their works prize; in particular it is an attempt to bind subsequent buyers of the work to royalties, which in the USA are not considered property rights (Frye, 2017). Basically, it is a template contract; it provides that in case of resale of the work of art, the original buyer is bound not only to pay to the artist a royalty of a certain amount, but also to use the same contract form

[3] These aspects of property rights have been pointed out by several authors and the references in the text do not claim to be complete

[4] For instance, see Cass 3e civ, 31 October 2012, 11-16.304, D.2012.

[5] It is common to find on the internet different variations of the Projansky contract; for example, here there is a form aimed at benefitting a charitable organization: https://artistcontract.org/ (last accessed 18/04/2023).

in any future sale, so that the subsequent buyer will be bound to the same terms (royalties included). The enforceability of this contract is, anyway, problematic, because it stretches the principle of the *numerus clausus*: it was argued that "the seller of the artwork cannot create a contractual right that will bind future buyers" (Frye 2017).

Another example of the demand for greater flexibility can be seen in the reification of claims, that has allowed to consider claims (agreement, but also contractual rights) as objects of property rights, and transfer them as tangible assets; a part of the literature has argued that the content of the agreement can shape the content of the property right itself (Akkerman, 2008).

2.2 The publicity system

The specific nature of property rights, i.e., the effects against third parties, requires the knowability of the property rights that burden an asset, of their owners, and of the occurrences that affect them. The point is to ensure that, from the one hand, every subsequent transferee knows which rights will bind him, and on the other that, when the asset is transferred, the consent of every owner is collected (Arruñada, 2003; Akkerman, 2008, 2017). As a consequence, the law system provides mechanisms that ensures the publicity of property rights. Obviously, this does not happen when contractual rights are concerned. The privity of contract justifies simpler ways to keep track of parties' reciprocal rights and obligations, in particular the contract itself (Hansmann & Kraakman, 2002).

There are several possible publicity mechanisms, but the parties cannot choose which to use. Instead, the legal system associates a particular mechanism to a (category of) property right of which it ensures the knowability. They are strictly connected, so that they can be considered together as a "property regime" (Hansmann & Krakmaan, 2002). The mechanism of publicity will be used to verify parties' understanding of their rights (coordination problem) and on the other to ensure that any breach will be easily detected and that the right will be enforced against the breacher (enforcement problem) (Hansmann & Kraakman, 2002). In other words, it is possible to say that the enforcement of the right as an *in rem* claim is conditioned to the respect of the publicity system (Arruñada, 2003). Furthermore, the mechanism of publicity affects the scope of categories of property rights: if it allows to take notice of adjustments made by the parties to the content of their rights, the scope will be wider, thus giving more flexibility to the *numerus clausus* (Arruñada,2003).

For the purposes of this research, the most important publicity mechanisms are the register and the record. The record keeps track of the deeds concerning a particular asset; it works as an evidentiary mechanism that will be used by courts to enforce property rights in case of litigation, according to the chronological criterion of first recording. It may contain contradictory deeds, because usually they are not controlled, except for some formal requisites. One of the advantages of the system, anyway, is that, as it keeps track of deeds and not of rights, it allows the parties to adjust the content of their rights to their needs; as a consequence, it allows a broader *numerus clausus* (Arruñada,2003, 2011). The register instead is based on rights, which it annotates orderly. As a consequence, defective and contradictory rights are purged before entering the register. Therefore, the information in the register is more certain (Arruñada,2003, 2011).

2.3. Justification of the system in the light of Coasean theory of transaction costs

Many authors have tried to justify the system above described, and, in particular, the *numerus clausus* principle. A significant part of such literature has focused on the relationship between the provision of a more or less flexible *numerus clausus* system with the efficiency of the market. In this view, a closed system facilitates achieving efficiency, as it leads to a decrease in transaction costs.

The premises of such a view reside in Coase's theorem, under which "with costless market transactions" the original decision concerning the arrangement of rights (every social, legal and economic organization which allows the exploitation of assets) "would be without effect on the allocation of resources" (Coase, 1960), as bargaining would lead to the most efficient solution. The author himself, anyway, recognizes that the assumption is "unrealistic (…):in order to carry out a market transaction it is necessary to discover who it is that one wishes to deal with, to inform people that one wishes to deal and on what terms, to conduct negotiations leading up to a bargain, to draw up the contract, to undertake the inspection needed to make sure that the terms of the contract are being observed, and so on" (Coase, 1960).

With particular reference to property rights, if there were not transaction costs, their organization in a closed system would be inconsequential, as the bargains would allow to achieve an efficient allocation of resources no matter what (Bucaria & Gottardo, 2023). However, as this does not correspond to the reality, property rights must be regulated to lower such costs. The principle of the *numerus clausus* in this perspective is justified in terms of a decrease in transaction costs.

In particular, Merril and Smith (2000) pointed out that an open system of property rights would create additional costs for third parties, connected with the additional information they will have to acquire to ascertain whether the asset that they want to purchase is burdened by a particular property right. Such costs of measurement should be lowered providing a selection of property rights with standardized content. The cost of creation of new rights must be balanced, anyway, to the frustration borne by parties that cannot customize their right with *in rem* effects: in this perspective, the higher or lower number of standardized rights available to parties is the result of a trade off (Merril & Smith, 2000)[6].

The most effective considerations on the point, however, were made by Hansmann and Kraakman (2002). The authors criticize Merril and Smith for missing the fact that in a law system there hardly are standardized rights whose content is predetermined by the lawmaker. Instead, they argue that the scope of the possibility of the parties of adjusting the property rights is individuated by the particular publicity mechanism ("verification rules" in the paper) connected with that category of property right, which may or may not allow to give notice of such adjustments. In this view, the flexibility of the *numerus clausus* depends directly on the verification rules adopted. Nevertheless, establishing and using such publicity mechanisms impose costs on the market. In order to achieve the efficiency goal, it is necessary to choose the mechanism which maximizes the difference between the benefits that the use of the right provide, and the costs connected with the establishing and functioning of the verification rule. In other words, property rights are constrained

[6] The point was firstly made in 1834 in the decision Keppel vs Bailey (mentioned also in Merril & Smith, 2000) where it was stated that "if parties were allowed to invent new modes of holding and enjoying real property (…) it would be hardly possible to know what rights the acquisition of any parcel conferred or what obligation it imposed".

in a closed system because the costs of establishing an open system outweigh its advantages; at the same time, a more or less wide freedom in determining the content of the right depends on a cost-benefit analysis. (Hansmann & Krakmaan, 2002).

Hansmann and Kraakman (2002) and Merril and Smith (2000) make a very important point for the purposes of this paper. Actually, it allows to study contractual and property rights beside the static perspective of the control on resources legally enforceable against others. Instead, it leads to consider a dynamic point of view that understands the trade of resources as a mean towards efficiency. In this regard, the value of their conclusions is twofold, both prescriptive and descriptive, as from the one hand they aim to find a reason behind the current property right system, and from the other hand, they determine the criterion that the law maker must follow to modify such system, and the issues that the modification should address, namely, the inefficiencies of the system that prevent transactions to occur. Both papers actually validate Coase's conclusion, that the law should aim to reduce transaction costs (Coase,1960).

Such conclusions lead also to a better understanding of what role is played by the law in the new institutional economic analysis. The authors that endorsed such an analytical framework have understood organized institutions and any form of cooperations between economic operators as structures to reduce transaction costs: for example, market and firms. Such structures internalize some of the transactions which before occurred outside them, smoothing the frictions that would have burdened and prevented some to even occur; in this sense, they represent an evolution of the more expensive transactions that take place outside them (Williamson, 1985). In the institutions the allocation and the control on resources can be realized by different means, that may or not be regulated by law. Nevertheless, the law keeps playing a fundamental role in the relationships with people and other institutions external to the organization itself, as property and contract law determine when the asset enter the organization and is allocated through its structure. As an example, law set the conditions to recognize the transfer of an asset to a legal entity, thus removing it from the assets that the shareholder's creditor can satisfy on.

3. Technological background

3.1. The functioning of the blockchain

To understand how the blockchain challenges the normal distinction between contract and property rights it is fundamental to have a closer look to the technological background.

The blockchain purpose is to allow digital payments without the intermediation of trusted third parties, as opposed to the more traditional e-coins. In this perspective, the barrier was the possibility to copy any digital object a potentially infinite number of times. This means, for digital coins, which basically are algorithms, the possibility to use the same value multiple times (double-spending). For e-coins the problem has been solved thanks to a third-party mediator (usually a bank or a similar entity) that processes every payment checking each transaction against double spending. In the blockchain, the solution consists in the creation of a tamper-proof ledger that keeps track of every transaction and that every user of the community can access. According to their creator, "the only way to confirm the absence of a transaction is to be aware of every transaction" (Nakamoto, 2009).

The result was the creation of cryptocurrencies, where the information connected with the coins are stored in blocks; when a modification occurs (e.g., the coin is transferred), another block is

added, and it refers to previous blocks thanks to a cryptographic pointer. The result can be thought as a chain of blocks (blockchain). In cryptocurrencies therefore the relevant information regarding the digital coin is embedded in its blocks, and the coin itself work as a ledger. When the coin undergoes a modification, it is timestamped, and the information are shared to every user (Clark, 2016).

Every modification of a cryptocoin is controlled with a peer-to-peer system. The first consensus mechanism that has spread in DLT is the proof of work (POW). In this mechanism, a modification of the ledger is proposed by a user, and then it is confirmed when the majority of the nodes in the community checks the solution to a complex mathematical expression (the hash). Nevertheless, the mechanism has showed its downsides when the increasing complexity of the hash and the significant computing power consequently required has resulted in the aggregation of nodes (mining pools) that substantially reduce the security of the system. As a consequence, different consensus mechanism has been invented and deployed, such as the proof of stake, where the validators grant the correctness of the validation by giving some of their crypto-chain as securities (Spinoglio, 2022). The immutability of the ledger relies on the incapacity of potential attackers to take control of the majority of the nodes; a potential attack is also made more difficult by subsequent transaction, which will imply that the attacker will have to redo not only the single transaction that he wants to alter but also all the blocks eventually added (Narayan & Bonneau & Felten & Miller & Goldfeder, 2016).

The development of the blockchain has led the enthusiast to rethink the purpose of the system: not only as a payment mechanism, but also as a way of transferring all kind of asset, included non-fungible ones. The first attempt in this direction took the form of Bitcoin “Colored Coins”, that can be referred to a particular output (Rosenfield, 2013). Lastly, the technological developments led to NFTs (Non-Fungible Tokens), which “aims to represent a given asset, be it digital or physical, on a blockchain” (Valeonti & Bifakis & Terras & Speed & Hudson-Smith & Chalkias, 2021). The ability of representing a particular (non-fungible) asset comes from its traceability on the system as it carries distinctive information (Bal & Ner, 2019).

As crypto-assets can now embed any kind of information (standardized or nearly-standardized, and unique) their function is not limited anymore to the payment (cryptocurrency). They also represent claim in services or other benefits (utility tokens); the spread of the blockchain in finance has also led to the creation of security tokens, which represents shares, bonds and other kind of commodities (such as gold)[7] . In some significant cases, documents evidencing claims on particular assets have been tokenized (title assets); finally, tokens have come to represent (property and contractual) rights on assets (commodity tokens or asset-backed tokens) (Lee, 2020). In other words, the blockchain has developed to a market where every kind of asset can be exchanged.

3.2. Smart contracts

The term “smart contract” is used in blockchain related paper to describe the code where the information regarding the token is embedded, and which define how the token will be traded in

[7] Security tokens are dealt with in OECD (2020), *The Tokenisation of Assets and Potential Impli-cations for Financial Markets*, OECD Blockchain Policy Series, 16 ff. Available at: www.oecd.org/finance/The- Tokenisation- of- Assets- and-Potential- Implications- for- Financial-Markets.htm (last access 18/04/2023).

the chain. Many blockchains use standard forms of smart contract to create the NFTs: the most famous one is ERC-721, provided by Ethereum. It is also quite common to give the possibility to draft individualized smart contracts (de Caria, 2019, 734 ss). They are run on blockchain and give automatic execution of the provisions embedded in the code. Therefore, similarly to real contracts they define the relationship between the parties who are involved in the exchange. The most significant platform where to run smart contracts is Ethereum, that is Turing-complete, allowing complex operations. Bitcoin instead is not Turing-complete, thus limiting its functionalities to the exchange of tokens (Cunningham,2016, 239 ss). Nowadays, with the widespread of forms of smart management of property, smart contract run on Ethereum can be used to manage also physical assets. A very simple example is a smart contract that gives the possibility to access a car providing the user a key lasting a particular amount of time, thus enabling new form for car sharing or renting[8].

The term "smart contract" however, was not coined in reference to blockchain and Ethereum. Nick Szabo firstly used it in a series of papers published since 1996. He defined smart contracts as "a set of promises, specified in digital forms, including protocols within which the parties perform on these promises" (Szabo 1996). He argues that contractual clauses can often be expressed as «if clauses», and thanks to the similarity with computer codes they can be "embedded in hardware and software (…) in such a way as to make a breach expensive"; in his view a basic example of smart contract is the vending machine: it "takes in coins, and (…) dispenses change and product fairly" thus concluding a sale (Szabo 1996). Relevantly, the terms as firstly used was technologically neutral; the main highlight was that the promises made between two parties are executed automatically thanks to a software or a hardware (De Molina Rius 2022).

The similarities with «legal contracts», derived from their abilities of regulating the relationship between the parties, has led a part of the literature to suggest that they should be recognized as legally binding agreements[9]. Actually, smart contracts should be considered in the light of the principle which are at the basis of the blockchain: the refusal of the traditional market institutions and regulatory authority, that, after the 2008 crisis, were not perceived anymore as trustworthy (Clark, 2016). Enforcing smart contracts in courts is not consistent with such values. According to blockchain theorists, the automatic execution is enough to prevent a breach of the agreement between parties. Or rather, it is even more effective, because while the law enforcement provides only a solution *ex post,* the code factually prevents the breach, operating before its occurrence (Cuccuru, 2017). Generally, whether the law system enforces smart contracts or not is considered inconsequential (Tasca & Piselli, 2019).

Their rhetoric is supported by the fact that they present the blockchain as a continuation of that phenomenon that Lawrence Leissig has summarized with the famous phrase "the code is law" (Leissig, 2006); Leissig studied the relation between technology and regulation, and argues that technology can be as compelling as law in defining the permitted individual behaviour. In

[8] "Blockchains: The Great Chain Of Being Sure About Things" (2015) available at http://www.economist.com/news/briefing/21677228-technology-behind-bitcoin-lets-people-who-do-not-know-or-trust-each-other-build-dependable

[9] For a clear explanation of the debate see Christopher D. Clack and Vikram A. Bakshi and L. Braine. "Smart contract templates, foundations, design landscape and research directions" arXiv: 1608.00771v3, 2017, but also Allen, Jason Grant. "Wrapped and stacked" in "Smart Legal contracts" edited by J. GRANT ALLEN, P. HUNN, Oxford, 2022.

particular, smart contracts define the rules that must be applied to the relationship between the parties and do not permit any default (Tasca & Piselli, 2019). It was even argued that the blockchain has outdated Leissig's "the code is law", and has led to a new phase of "code-ification of law": in this view, not only the blockchain strengthen the compelling qualities of technology, as it does not just prevent a particular behaviour, but enforces the rule itself: the law too will undergo a modification that will make it more similar to the code to ease its expression by algorithms (De Filippi & Hassan, 2016).

This view must be read in the light of the evolution of the legal-philosophical thought. Traditionally, the legal philosopher had assumed that the world is pre-existing and external to the subject, and that the legal status of the asset is defined by its features. The technological development, and in particular, the possibility to shape the asset has enhanced the creative power of the subject; in this perspective, the producer of the asset plays a fundamental role in determining the applicable rules, so that it is possible to talk of things-by-design (Madison, 2005). Such creative power has been strengthened with digital products and the ability of incorporating the rule in the asset itself by code. The blockchain has something more, as it brings with itself a refusal of the law and enhances the self-executing performance of the rule by running the code in a tamperproof platform.

The blockchain finds its roots in a libertarian attitude that does not trust in centralized organizations, law and States above all, and seeks to rediscover the power of the individual (De Caria, 2019). Obviously, anyway, this phenomenon too cannot be considered in a legal void. Firstly, even in the blockchain the principle of the «code is law» has been proven itself a great deal more malleable than what suggested by the early commentators. A code is a tool, which can be mistakenly used: there may be a lack of correspondence between the intentions of the parties and the code, or there might a vulnerability of the code, so that it is open to external attack (Sir Vos, 2022). In this case the legal enforcement becomes compelling, and it is evident that is not possible to consider the blockchain as in a legal void. Secondly, when considering asset that could be traded also off chain (i.e., outside the institution), namely, when real-world assets are involved, competing claims could arise from contradictory contracts. The consensus mechanism successfully prevents any form of double spending on chain, thus making impossible transaction of rights incompatible the one with the other; nevertheless, it cannot prevent that a contradictory right is agreed upon on chain (Woxholton & Zetzsche & Buckley &Arner, 2023). Thus, it would be necessary a legal solution of the litigation.

3.3. Conveyance of rights through the blockchain

As above said, transactions on blockchain are validated through the consensus of the community of nodes. Therefore, it provides an organizational structure where resources are allocated to the member of the community regardless of respect of conditions required by private law to recognize such control.

According to the literature (Arruñada, 2018; Garcia-Tuerel & Simón-Moreno, 2021; Borgogno 2022) a mere exchange on the blockchain would not be able to transfer a property right. As above pointed out (2.2) any transfer of property right must adhere to the publicity regime established by law in order to be effective outside the parties directly involved; despite the fact that the

blockchain is quite effective in granting the knowability of exchanges among the users' community, it must be recognized by law before it could affect real-world property rights allocations. Besides, in order to transfer the ownership on an asset, it is necessary to collect the consent of every property right owner; not all of them though, may have tokenized their rights on the (same) blockchain (Arruñada, 2018). In this sense whenever a token representing a right on a real-world asset is transferred on chain, "the legal effects of such transfer would be limited to the transferring parties" (Arruñada, 2018), as it would be unable to create *in rem* effects.

This is the case, for example, of DAOs, which are entrepreneurial organizations whose decision-making process and activities are run through smart contracts on the blockchain. As it is usually required a recognition by the law system for corporations to be subjected to a limited liability regime, in absence of such a recognition the DAO participants will bear the consequences of unlimited liability towards the DAO creditors (Borgogno 2022).

The acquisition of *in rem* effects is conditioned to the compliance with the publicity regime: the parties who want to transfer property rights on the blockchain will have to take them into account, and operate accordingly; if necessary to abide to such regimes, they will have to take actions concurrently with the blockchain exchange (Garcia-Tuerel & Simón-Moreno, 2021). Obviously, sometimes the transfer on-chain suffices to meet the condition of publicity. For example, if it consists of the consent of the parties, it can be argued that the smart contract, or the underlying agreement, is enough to prove it (De Caria, 2019). Instead, if a notice in a public register is required, the parties will have to abide and register the transfer separately: the blockchain, despite organizing itself as a ledger, is not recognized as a public register (Garcia-Tuerel & Simón-Moreno, 2021). On the contrary, a blockchain exchange would be able to transfer rights with *in rem* effects if the blockchain was recognized as publicity mechanism for such transfer by the legal system. In such directions goes a pilot project initiated in Sweden, where the blockchain has substituted land registries (*Lantmäteriet)* as an attempt to cut the costs and improve the efficiency of land conveyance[10].

The situation is not be that different when smart contracts are involved, for example by providing the transferee of the token with a digital key to access and use its property. Even in this case, the parties (if they do not comply to the additional publicity regime established in the law system) will transfer only the possession of the asset (Arruñada, 2018).

As a consequence, if the transaction on chain does not meet the conditions determined by law it won't be recognized any judicial remedy to the malfunctioning of the code or the breach of the smart contract due to an external attack. Similarly, when competing claims are concerned, a transaction on chain will not legally prevail against a contradictory one off chain; in this perspective, it is not true that the legal system would not be able to solve the litigation among competing claimers (as suggested by Woxholth & Zetzsche & Buckley & Arner, 2023 6 ss). On the contrary, it simply means that any litigation of competing claims will be solved against the blockchain transaction, because it cannot convey property rights. Obviously, this legal reasoning would disappoint the expectations of economic operators, who actually were convinced that the

[10] For more information see Ålander & Larsèn, & Lindberg, 2022 at https://practiceguides.chambers.com/practice-guides/blockchain-2022/sweden/trends-and-developments

transaction on chain could transfer legally enforceable property rights, without the need to comply to any particular publicity system (Woxholth & Zetzsche & Buckley & Arner, 2023, 18). Furthermore, when talking about blockchain transaction it is not always easy to determine the governing law, and consequently the required publicity mechanism (Woxholth & Zetzsche & Buckley & Arner, 2023). Undoubtedly, parties will be discouraged from using the blockchain; thus, they would avoid to use a technology that, at least for some contract, could succeed in reducing transaction costs.

As such an outcome is quite undesirable, it has been proposed (Woxholth & Zetzsche & Buckley & Arner, 2023) that the blockchain could be recognized as a publicity rule. In other word, that it could be recognized as a way to legally transfer property rights already. The resolutive criterion to adopt when deciding if adopt such a publicity mechanism should be based on efficiency, and in particular, on a transaction costs analysis. According to the majority of literature (see right below) the blockchain is promising in this respect; nevertheless, this paper follows pointing out a technical feature that could make transactions more expensive, at the same time challenging the use of the *numerus clausus* principle.

4. An evaluation of the potential of blockchain as publicity mechanism

4.1. Explaining the hype. The narrative of transaction costs reduction.

The choice to evaluate the use of the blockchain as a publicity mechanism on the basis of Hansmann and Kraakmaan most famous research must be understood in view of the fact that (at least partially) the hype around the blockchain is due to its claim to reduce transaction costs. The point is based on the fact that it allows new form economic coordination, by providing the participant of the community a new way to reach consensus and validate economic facts and thus competing against other capitalistic institutions (Tapscott & Tapscott,2017; Davidson & de Filippi & Potts, 2018,11).

In particular, the blockchain has been described as “a self-governing organisation with the coordination properties of a market, the governance properties of a commons and the constitutional, legal and monetary properties of a nation state” (Davidson & de Filippi & Potts, 2018, 16). This definition highlights the absence of a hierarchical structure, the ability to smooth transactions and to get a community to agree on the validity of a transaction on the basis of primary rules expressed in the protocol.

The premise is that transaction costs affect economic operators, so that they are led to organize structures where transactions are internalized; as a consequence, the transaction costs that would arise from many different trades are significantly reduced (Coase, 1937). How much to internalize in the organization is chosen on a trade off basis: in particular, based on the comparison between the expenses that a market transaction will require the ones required by the embedding of the same transaction in the organization structure. Three different level of decision are the outcome of such trade off. The structure of the organization, what relations are to be internalized, and how many and which employee to hire (Williamson, 1981 and 1985).

In this perspective, the introduction of an innovative technology, such as the blockchain, that changes substantially how people exchange assets will inevitably affect such costs, and thus shift

the balance of such trade off. As above said, the cxmajority of the literature seems rather optimistic on the possibility that the blockchain will lead an increase in the overall efficiency of the system, by reducing transaction costs. Such literature is relevant for the scope of the paper, actually, not only because it explains the hype surrounding the blockchain itself, and why so many people have proposed to implement it in everyday transaction, but also because it allows to consider how the current property rights system will be affected.

4.2. The literature concerning transaction costs in the blockchain

It is important to understand that the literature about transaction costs in blockchain has dealt with the topic in a particular framework: the one considered in the last paragraph, commonly known as New Institutional Economics (NIE). As a consequence, they have analysed the transaction costs that economic operators can use blockchain to cut, and the costs that instead blockchain could increase.

In particular, technical features that allow to cut expenses have been spotted. Firstly, the blockchain allows to keep track of the transactions validated by the community on a distributed and immutable ledger. Every node in the blockchain can access the ledger and verify the conditions and the object of any transaction. The second relevant feature is the automatic enforcement of smart contracts, which relieves the uncertainty of the execution of the agreement (among others, Davidson & de Filippi & Potts, 2016; Catalini & Gans, 2016, revised version 2019; Schimdt & Wagner, 2019; Ahluwalia & Mahto & Guerrero, 2020).

Such technical features are precious especially at the earliest stage of the transaction: Actually, the distributed ledger leads to increase in transparency in comparison with similar trades of assets with comparable characteristics (McMurren, Young, Verhulst, 2018). During the bargain, it provides an easy access to reliable information concerning the features of the token and its previous transactions on-chain. As only validated transactions enter the ledgers, and due to its immutability, it substantially reduces the risk connected with the purchasing of an asset of not sufficient quality, or burdened by other rights (as long as the other rights too are recorded and traded on chain). Having access to enough information concerning the quality of the asset also reduces the need for reputational information and the costs of intermediaries to get it (Catalini and Gans, 2016, revised version 2019). Actually, the reputation of the counterparty will be easily verified by accessing data concerning previous transactions, which would signal any misbehaviour (Schimdt & Wagner, 2019, 5). Furthermore, during the execution of the contract, the ledger allows to keep track and easily verify terms and conditions of the agreement. Also, it gives the possibility to collect information on the arrangements and preparatory work, thus facilitating the evaluation of the performance (Schimdt & Wagner, 2019, 5 ss). Lastly, in comparison with off chain ledgers and registers, the blockchain allows a decrease in the time taken to record the transaction, thus reducing the scope of error and enhancing the accuracy of the ledger (McMurren, Young, Verhulst, 2018).

As for the automatic enforcement of the smart contract, it eases trades by making (nearly) impossible a default of the agreement. In this perspective, the blockchain relieves uncertainty concerning both whether the performance will be executed and whether it will respect the agreed standards (Sklaroff, 2018; Schimdt & Wagner, 2019, 5). Furthermore, a smart contract, being expressed as conditional clause (if… then), allows to take into account an incredible number of

contingencies that can affect the desired outcome, and that in traditional contract would lead the parties to modify their agreement. Thus, it erases any costs connected with new negotiations and bargaining (Davidson, de Filippi, Potts, 2018). The resulting contract is complete as it considers every case which is relevant for the agreement between the parties (Grossman & Hart, 1986).

However, not all the literature has shown such an enthusiasm. Especially, the idea that the completeness of the smart contract will be the source of economies in term of transaction costs has been criticized. It has been pointed out that the automatic execution of the smart contract leads to the output determined by parties, and there is not any chance to adapt the contract during the execution phase: necessarily, the relevant contingencies for the performance will be only the ones predetermined by the parties, so erasing all the competitive advantages that an incomplete contract usually provide (Vatiero, 2018 and 2022; Sklaroff, 2018). In particular, if even it is possible to write a complete contract, it involves costs related to the necessity of correctly determining all the possibilities that could affect the contract (Szczerbowski, 2018); while the tracking capacity of the blockchain will provide all the relevant information concerning relevant on chain occurrences, this is not true for events external to the blockchain. Those could be of some importance especially if the token traded on chain represents an off chain asset. Moreover, when writing the smart contract, the parties won't benefit from the flexibility of legal language, that allows not to specify all the different shades of possibilities that fits into a particular concept (e.g. the bona fide) (Vatiero, 2018), because as above (3.2) said, the smart contract is not phrased in semantic language, but as a code. Furthermore, as the smart contract is supposed to be automatically enforced and immutable, the required precision is not mitigated by the possibility of a further intervention of the parties or of an external authority; differently, a traditional contract allows the intervention of the judge to provide remedies and determine rights and obligations that the parties have undergone by interpreting the terms (Vatiero, 2018 and 2022; Sklaroff, 2018). In this perspective, the *ex ante* precision is correlated to an *ex post* impossibility to adapt the code any not considered event should occur.

Also, as the protocol is updated thanks to the determined consensus mechanism, it is possible that miners intervene on the code to make it more agreeable to their needs. In this sense it would arise the traditional issue of the dictatorship of minorities, where the power of few could be used against the interest of the majority (Vatiero, 2018 and 2022).

Anyway, this does not mean that, at least for some kind of contracts, it is impossible that the blockchain could help saving transaction costs. Foreseeably, such inflexibility will burden transaction on chain in different ways. In particular, it will result in a greater increase in transaction costs whenever the performance (the output) of the smart contract would have been easier evaluated during the execution (Sklaroff, 2018). On the contrary, it won't weight too much on transaction costs when it is easy to determine that the performance will satisfy the parties' interests, and the contingencies that could affect it are easily predictable.

4.3. A cost-benefit analysis

The analysis required to apply Hansmann and Kraakman theory (2002) is broader than the one considered by the previous considered literature. Actually, the last has focused on the costs borne by economic operators that the use of the blockchain can prevent, reduce, or, instead, raise.

Instead, as the conditions to abide to in order to transfer property are stay the same, it does not consider all the other transaction costs (for society, and non-users). For the very same reason (namely, equal and opposite, because the paper takes into account a change in the publicity mechanisms) it is not possible to overlook the fact that the evaluation of a publicity mechanism requires that all costs connected to the mechanism are considered; and in particular, besides the ones borne by the parties, the costs to establish it and to keep it working and to allow non users to check it.

A clarification of what above said is, nevertheless, useful: the above recalled features, and particularly the tracking system and the automatic enforcement of the smart contract reduce brilliantly the problem of giving notice to the existence of propriety rights on an asset, as the data of the ledger are spread among all the nodes of blockchain. Also, due to the automatic execution, transferring the complete property of an asset already burdened by a partial right will necessarily require the consent of the partial right owner, because it will be necessary a reverse transaction to cease the effects of the smart contract. In this sense, it does not leave any space for uncertainty neither for opportunism that could require a judicial enforcement. This does not mean that no costs are borne to trade on chain: as above said, new expenses arise from the necessity of considering all the contingencies that could affect the performance, for example.

However, there are actually some concerns on the costs that the blockchain imposes on the society. Even though the blockchain is digital and stored in all the nodes of the community, that does not mean it is costless for the community. At the moment permissionless blockchains are private, and therefore the cost connected to write and update the code do not fall upon the society in its entirety, but on investors and proprietors (for permissioned blockchain), unless for opportunity cost of not investing in other activities. The society will bear also the costs connected with the carbon footprint of the industry, which is significant due to the huge computational power required to validate transactions on chain (Krugman, 2018). While such costs can weight significantly on the use of the chain, different consensus mechanisms are spreading, that should allow to reduce the required power.

There are more aspects that can be taken into account when reflecting on the costs that the blockchain imposes. Particularly, it is imperative to grant everybody access to the information stored on chain in order to verify if a partial right or an asset has been tokenized and consequently transferred. The topic is huge, because while there is plenty of websites which allow to browse public chain (Blockchain explorer) also the problem of digital literacy must be taken into account: as the population is averagely becoming older and older, it is impossible to imagine that the blockchain will be so widespread (and elder-friendly) that everybody could access easily such new technologies, at least at the moment. Furthermore, whenever a token representing a real-world asset is involved, the issue of coordination between physical and digital world arises.

As for the benefits that it is possible to think that the use of blockchain will increase the value of the right traded; this is particular true for example for the rights on asset that could benefit a digital and easily portable representation in the form of NFT, that could improve also the understandability of the information concerning the asset, as it happens for land and work of art. In many cases, the NFT has even become part of the art itself: the phenomenon is shown by art

exhibitions that display both the digital representation (connected with the NFT) and the physical object, its embodiment.

At the end of this analysis, the question posed at the beginning of the paper, whether the blockchain should be considered a publicity mechanism able to transfer propriety right is very difficult to answer. Obviously on the uncertainty weighs the lack of an empirical and quantitative analyses. Thus, in the limited scope of this qualitative research, it is possible to give an inevitably partial and temporary answer. Particularly, that the answer could be positive at least for certain kinds of rights on certain assets, that could take the best advantages from the visual and easily storable representation.

5. How the blockchain challenges the traditional distinction between contractual and property rights and the *numerus clausus* principle

5.1. Effective contractual running rights

Unfortunately, competing claims can hardly be solved efficiently when on chain and off chain transaction are involved. The functionalities of blockchain works as architectural constraints (Leissig, 2006), and any regulation of the phenomenon must take them into account (Lehdonvirta & Ali, 2016) In particular, some concern regarding the compatibility of the code with the *numerus clausus* principle may arise. As noticed above, the blockchain is particularly useful to transfer propriety rights. In this perspective it seems that the automatic execution of the provisions embedded in a smart contract is able to create a direct relationship between the owner and the assets, granting a control on the resource that can be opposed to subsequent purchaser; in this perspective, in the blockchain the transfer of a right has effects comparable with the legal *in rem* effects, deriving directly from its technical features. The problem here is the fact that such effects, being connected with a technical feature, occur independently from the nature of the right transferred on chain whether it is considered as contractual or property right by the law system. This leads to a contradiction between the legal rule and the code.

A first example of this phenomenon can be seen in OpenSea. This is an open and permissionless platform that runs on Ethereum and allows the creation and the exchange of NFTs, usually representing works of art. Among the functionalities that it offers to its clients, it gives the possibility to individualize the smart contract deployed in the blockchain. Actually, the platform tries to keep the creation of NFTs very simple: in particular, it makes available basic smart contract providing a precompiled basic code; additional features can be added if needed. In particular, the user can opt to charge fees to any subsequent sale of his NFT. According to the information given on the website “one of the most exciting reasons to use OpenSea is the ability to earn revenue from secondary sales on items. Every time an item is sold on OpenSea, the project owner (you!) can take a percentage of the sale as revenue. This means that you can not only earn money from selling your initial set of items to users, but you can continue to earn as your game and marketplace heats up!”[11]. In particular, these functions allow the original creator to receive a percentage of the sale prize whenever the NFT is transferred, as it is provided in the smart contract, which set the conditions of the exchange and gives them automated execution. The

[11] Opensea, For developers, Setting fees on secondary sale, https://docs.opensea.io/docs/10-setting-fees-on-secondary-sales updated 03/2023. Last access 15/04/2023

result is that the fee provision regulates the relationship with subsequent transferee and gives automated enforcement of the creator's right to the fee against any buyer.

The situation above described is similar to the one crated with the Projansky contract. In both cases the necessary repetition of the clauses of the original contract creates a "contractual running right" (Hansmann & Kraakman, 2002), whose effects are substantially *in rem*, as it can be opposed (and automatically enforced, in the OpenSea case), to any subsequent transferee of the asset. Both these contracts blur the traditional distinction between property and contractual rights. In this case the blockchain does not show any disruptive innovation in respect to the traditional instruments of contract law. Nevertheless, there are some significant differences with the «traditional contractual version ». Firstly, from a practical point of view, while the «Artist's contract» was seldomly used, this OpensSea functionality is widespread in the community. Secondly, the «Artist's contract» would have been pretty difficult to enforce in courts, due to the general suspicion that a similar stretch of typical contractual rights effects had arisen (Frye, 2017). Instead, in the blockchain the automatic execution provided by the code prevents the breach of the provision and ensures the protection of the artist. Obviously, the problem of court enforcement will arise again in case of malfunctioning of the code.

Actually, such a situation occurs every time a partial right is embedded in the terms of the smart contract: it is not limited to the case of royalties in OpenSea; nevertheless, this example is particularly fitting, due to the correspondent real-world Projansky contract. Anyway, the discrepancy between the traditional distinction between contractual and property right and of the *numerus clausus* principle goes further.

5.2. The creation of a direct relationship with the asset

Let's consider again a "time-share" right on an asset. As pointed out above in 2.1. (relying on Merril & Smith, 2000) it is not included in the interests protected by law as property right, and therefore it could not have any *in rem* effects.

One may wonder, what if the time-share right on the asset was tokenized and exchanged in the blockchain? The owner of a car could create a NFT that represents a right to enjoy a car every Monday. The smart contract could provide a key to access the car that works only on Monday; every other day the car would be accessible with a different key. When the NFT is exchanged on chain blockchain, this partial right on the car is granted to a third party. Afterwards, the owner of the car (and original creator of the NFT) sells the car to someone else, outside the blockchain; he provides the new owner the key that he had used to access the car, thus transferring the possession of the good. Nevertheless, he does not mention the existence of the time-share right; maybe because he wanted to sell it for a higher price, maybe because he has read Merril and Smith's "*Optimal standardization in the Law of Property: The Numerus Clausus Principle"* (2000) and he is sure the new owner is not bound by the partial right he granted. Nevertheless, because of the automated execution of the smart contract, the key he has provided to the buyer of his car will not work on Mondays. The partial right represented in the NFT will be automatically enforced against the subsequent transferee. If he wants to get the possibility to use the car every day of the week, Mondays included, he will have to get the consent of the NFT owner and buy the NFT itself.

A time-share right on a chattel is not protected by law as a property right. Nevertheless, the effects that law usually reconnects to property right (the possibility to enforce the right against any subsequent transferee, independently from the transferee's consent; the necessary consent of all property right owners to transfer the asset) are achieved *de facto* by the automatic execution of the provision embedded in the smart contract. A similar issue would have arisen if the content of the right granted through the blockchain had been included in the categories protected by property law. If the parties have not abided to the publicity regime, the law does not give the agreement *in rem* effects. The automatic execution of the smart contract, however, will achieve the same result as law enforcement.

It seems that the automatic execution has created a direct relationship between the owner of the contractual right on the asset and the asset itself. The fulfilment of his interest is not conditioned anymore to the cooperation of the grantor of the right and is directly enforced against any subsequent buyer. Such relationship is similar to the one provided by the law system for property right, with the not irrelevant clarification that it is a *de facto* relationship: actually, it relies on the fact that technology can constrain the behaviour of the parties, and as in this case, give immediate and automated execution to the promised performance. The direct relationship between a property right owner and the asset, instead, is a legal bound, which is enforced *ex post* in courts. Obviously, the situation becomes messy if the possibility of a malfunctioning in the code is taken into account: in this case, probably the court will enforce the claim in the NFT as a contractual claim.

5.3. The enforcement of property law

The recalled examples show that on chain there is not any difference between (legally) property and contractual rights. The DLT consent to transfer both of those rights on assets (both as token or embedded in a smart contract), keeping track of the validate transaction and ensuring the automatic execution. Now, this should not be a problem: many publicity mechanism are used to transfer property rights and contractual rights: e.g., if according to the law, a property right is transferred whenever the party consent to the transfer, a contract will be a sufficient publicity mechanism. Nevertheless, the situation is overcomplicated by the technical features of the blockchain, that mimic the effects of *in rem* rights.

Consequently, the implementation of property law will require to undo the effects of the smart contract in order to allow the new owner to enjoy the unhindered control on the asset. Given the impossibility to edit the chain, the only viable way to reach such result is to yield the control of the token to the subsequent transfer of the asset, by an equal and opposite on chain transaction or by giving him the control of the blockchain account (Woxholth & Zetzsche & Buckley & Arner, 2023). Any subsequent transaction of the property right will require, in other words, the knowledge and the consent of the beneficiary of what should otherwise be a contractual right.

Obviously, this leads to inefficiencies. It is enough to think that to transfer the property right on the asset would be require another transaction on chain. The total amount would consequently be three: the first one that originally gave a (contractual) right on the asset on chain; the second one to undo the first, and the third to transfer the property right on the asset. Another issue is connected with the likely increase in court litigations. The consequence would be the increase in

transaction costs connected with the transfer any asset that has been tokenized on chain; at the same time, it would discourage from the use of blockchain to tokenize contractual rights on assets and transfer them on chain, thus precluding the use of a technology of great potential. Paradoxically, the application of the *numerus clausus* principle result in an increase of costs overall borne to allocate the control on resources. The contradiction with its purpose (already discussed in 2.4), namely, to grant efficiency, is evident. Such a result is discouraging. It could lead to the conclusion that blockchain should not be used at all, because there are high costs connect with its use.

5.4. Harnessing the potentiality of blockchain. Viable solutions to the increase in transaction costs.

Transaction costs above described are the product of a discrepancy between the law and the code. Some alternative solutions ca be proposed. Firstly, the blockchain protocol could be changed in order to have the law and the code to coincide. For example, the code could allow the blockchain user to include in the smart contract a clause whose effects would cease in case of an incompatible property right on the asset is transferred off chain. Obviously, the actual inserting of the clause would be conditioned to the voluntary agreement of parties; if the parties were not to use it, only an *ex post* legal enforcement could oppose the property right of the subsequent off chain transfer, with a consequent increase in the costs of the transaction. A more effective solution could be to compel such clause whenever contractual rights are traded as NFT. The implementation via code would automatically insert the clause in the smart contract, which would give it automatic execution. Again, it is also possible to use entry restrictions to prevent that contractual rights are tokenized ore inserted in the transaction.

The choice to change the protocol should not be left to the voluntary acceptance of individual blockchains, but instead should be the object of a legal obligation. This is viable especially when the blockchain is permissioned, as it will be possible to legally compel the proprietor into introducing such change in the protocol. It will be impractical instead, in permissionless blockchain, where the code is updated by several individuals and institutions, without a clear governance system (Lehdonvirta, Ali, 2016). Furthermore, due to the risk of hard forks, the change of protocol should be limited to transaction subsequent to the update of the software. This would let the transactions already occurred vulnerable to litigations. Another difficulty must be taken into account; while the Western legal tradition shares a basic common understanding of the categories of property right, there are differences in how much flexibility the parties can use to adapt the content of property rights.

Another solution that could be considered is based on the modification of the law system in order to grant more flexibility to the current property law system: in particular, this would imply to recognize the rights transferred through the blockchain as having *in rem* effects: sometimes, just granting a greater flexibility in defining their content; sometimes instead recognizing new kind of property right, that can be considered similar to servitude on chattel. The point is where to draw the line: not every right transferred through the chain could be efficiently recognized as a property right; again the decision should be based on a trade off, that considers for what rights, on which particular category of asset, it is cost effective such a recognition.

5.5 The efficiency of increasing the flexibility of the numerus clausus

Obviously one thing is to consider that a particular and already recognized category of property rights could have a more flexible content if blockchain was used as a verification system, and a totally different thing is to imagine the possibility of introducing (obviously by law and in *de iure condendo* perspective) a different category of property law. Actually, it is true that the reference of servitudes on chattel would lead any legal scholar to turn up their nose. The mere idea is pretty uncanny, as there is a widespread and longstanding tradition (Chafee, 1928) not to recognize any form of servitude on chattel, shared both by civil and common law. The exceptions are few and in the majority of cases the content is predetermined by law (Robinson, 2004).

The reasons that lead to consider such idea must be understood in the light of similar proposals that have been made with regard to patentable software. From a legal philosophical point of view can be understood seamlessly in the arguments that refers to "things by design". According to this school of thought assets are not conceived anymore as something existing outside the subject, with features that relevantly define its legal status. Instead, the relationship between the subject and the asset has been rethought by the legal philosophers. Accordingly, "things-by design" is used to describe the product of a manufacturing process, whose characteristics and legal status are at least partially individuated by the producer itself (Madison, 2005). This argumentation finds its roots in the Hegelian thought, and on its attention to the creative ability of the individual who can successfully impose his will on the surrounding environment to create and define things (Madison, 2005). The reference here is to the deployment of running smart contract on chain: particularly to the possibility to create a bond between the contractual rule agreed by the parties and the asset itself embedding it in the smart contract, which is automatically enforced. The concept of things by design has spread among the legal community especially with the so-called "Internet of things" where the presence of a licensable software embedded in the object was able to effectively constrain the use of the purchased asset[12].

At least partially, the battle has been fought on the ground of efficiency. One of the reasons that historically has led to deny a property status to servitudes on chattel is the generally acknowledged difficulty to give any form of notice to these partial rights; the costs of the publicity system in this perspective would not even be compensated by the high value of the transaction, as traditionally rights on chattels does not have such a value (Bucaria & Gottardo, 2023, 40 ss). Obviously, other concerns have played an important role: in particular, competition issues have been arisen (Chafee, 1928). Keeping the focus on the efficiency, it has been argued that the notice system has been advanced enough to solve this issue (van Houwelling, 2008).

If this is the discrimen, the tracking features of DLT technology, can be a resolutive feature. Consistently with what above pointed out, the justification for a changing in the scope and number

[12] For example, it was pretty (in)famous the coffee machine designed to make coffee only with capsules of a particular brand. To this purpose, a software was embedded in the machine, which verified the identification number on the capsule; otherwise, it politely refused to prepare coffee with a message on the screen (Perzanowski & Schultz, 2018). The limitations to the use of the coffee machine derives from the fact that the buyer has acquired the hardware (the coffee machine) and a license to use the code embedded in it; the manufactured instead retained the intellectual property on the software and the way it works. As a consequence, the buyers enjoy "not the coffee maker *in its entirety* (…) but all its utilities *minus* the possibility to freely choose the brand of the coffee pods" (Bucaria & Gottardo 2023).

of the property rights regime of servitudes could be justified only if allowed by the publicity mechanism, and if the benefit-cost maximization test keeps having a positive result. In this perspective, an accommodating property regime usually leads to an increase in the costs to check the existence of the right (Hansmann and Kraakmann 2002).

In this perspective, every user has the latest version of the ledger. Whenever a transaction takes place, it is registered and spread among the nodes. Anyway, as tokenized physical assets are concerned, the asset has both a physical dimension and a digital representation (the NFT). And, currently, it lacks a bond between the two of them that could prevent a discrepancy between what is registered on chain and its status off chain. While blockchain browsers are available, at least for public ones, they are a tool that requires to check online and to spend some time looking for the information concerning the asset. This is costly, at least in term of opportunity cost; widening the number of rights that can be exchanged on chain and their scope implies an increase in such costs. The costs are higher if people involved do not have a great digital literacy.

Again, a precise answer require data from empirical research, that at the moment are still to be carried.

6. Concluding remarks

The blockchain technology has posed a series of challenge to the legal system. This paper offers a reflection on one of them and attempts to provide some solutions. In particular, the it lies in the fact that the blockchain is not able to solve the double spending problem when the traded token represents a real-world asset, as it can also be transferred off chain. The lack of reliable means of coordination between the on chain ad off chain environments is one of the causes of the problem. The principle traditionally used by the legal system to solve competing claims on the same asset is the *numerus clausus* rule, which distinguishes between property and contractual claims; such a principle finds its rationale in an efficiency goal, and in particular, in the reduction of transaction costs that burden the economic operators.

Two examples show that this principle cannot be used efficiently in the blockchain. The blockchain protocol mimics the effects of a classification as an *in rem* right, but without differentiating between a legally contractual and a legally property right. Thus, whenever a property right is legally opposed against a contractual claim embedded in a smart contract, another transaction is necessary to delete such effects. The consequent increase in transaction costs makes the *numerus clausus* principle unsuitable to reach its efficiency goal. As the phenomenon can be understood as the product of a discrepancy between the code and the law, two alternative solutions are proposed. The first one is the adaptation of the code to the legal system. The other one is to legally recognize the blockchain as a mean to transfer property right, but to increase the flexibility of the *numerus clausus* as much as it is possible given the transaction cost imposed by blockchain on non-users to verify the existence of a right.

Neither of those solutions are completely satisfying. While the first is difficult to apply, the second challenges longstanding legal traditions and its cost-effective implementation would anyway require data that are not available at the moment.

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