Property Without Law: Personalized Property Rights Through Smart Contracts on the Blockchain

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Emerging technologies for the automatic enforcement of contracts, conventionally referred to as smart contracts, have the potential to realize Professor Alan Schwartz's ideal of an efficient contract law for sophisticated parties, as they reduce the cost of textualist enforcement, added contingencies, and privately-provided templates, and offer a way to get around mandatory rules relating to such matters as contract modifications, penalty clauses, and substantial performance. They also enable contracting parties to create personalized property rights free of legal restraints. Through automatic enforcement, a contract term can be directly included in contracts with subsequent transferees of the asset. Smart contracts thus turn mere contractual rights into de facto property rights that "run with the (digital) asset." Breach is made impossible by the very nature of the automatic enforcement system, and notice is assured by distributed and readily accessible ledgers.

Compared to traditional property rights, these "property-without-law" rights are more easily customizable ex ante—as they are not bound by the numerus clausus *principle—and stronger ex post—because courts cannot modulate enforcement. We document this phenomenon, explore its potential and vulnerabilities, discuss examples in intellectual property, real estate, organizations, and financial contracts, and re-examine the role of property law in a world where technology, rather than law, turns promises into assets.*

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Introduction

Contractual rights are bound by privity but graced with freedom of contract; that is, they operate only between the contracting parties (*in personam*) but parties are generally free to design contracts however they wish.[1] Moreover, parties cannot contract for specific performance (a *property rule*) and are most commonly awarded damages (a *liability rule*) in case of breach.[2] In contrast, property rights are in rem, that is, they avail against the world as they "run with the asset", and can thus be enforced against subsequent transferees of other rights in the asset, irrespectively of their agreement. At the same time, parties' ability to create property rights is limited by the *numerus clausus* principle to a small set of legally sanctioned rights; only the legislator can create new property rights.[3] Also, property rights are usually—though not always—enforced through the property rule of specific performance.[4]

In the several areas of the law in which property rights are recognized—thus, not only in the law of property of physical assets, but also in securities law, intellectual property law, agency law, and the law of legal entities—the state retains two control levers over the boundary between property and contract. Ex ante, parties are limited in their ability to create rights in rem because providing *notice* of property rights to third parties who could be affected by them is expensive.[5] Ex post, if property rights

1. Contract law contains default rules that are meant to fill the gaps in incomplete contracts and a limited number of mandatory rules that cannot be altered by the parties. On default rules, see Alan Schwartz & Robert E. Scott, *The Common Law of Contract and the Default Rule Project*, 102 VA. L. REV. 1523 (2016). On mandatory rules, *see* Alan Schwartz & Robert E. Scott, *Contract Theory and the Limits of Contract Law*, 113 YALE L.J. 541, 609 (2003) and Alan Schwartz & Simone Sepe, *Fairness and Freedom in Contract Law* (working paper) [https://perma.cc/M3GX-792M]. On the trade-off between incentives, drafting and litigation costs in contract design see Robert E. Scott, *The Paradox of Contracting in Markets*, 83 LAW & CONTEMP. PROBS. 71 (2020) and Robert E. Scott & George G. Triantis, *Anticipating Litigation in Contract Design*, 115 YALE L.J. 814 (2006). On a theory of the optimal altering rules, the rules that discipline how parties can alter legal defaults, *see* Ian Ayres, *Regulating Opt-Out: An Economic Theory of Altering Rules*, 121 YALE L.J. 2032 (2012).

2. On the distinction between property rules versus liability rules, see Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089 (1972).

3. Henry Hansmann & Reinier Kraakman, *Property, Contract, and Verification: The* Numerus Clausus *Problem and the Divisibility of Rights*, 31 J. LEGAL STUD. S273, S274 (2002); Thomas W. Merrill & Henry E. Smith, *Optimal Standardization in the Law of Property: The* Numerus Clausus *Principle*, 110 YALE L.J. 1 (2000); Henry E. Smith, *Standardization in Property Law*, in RESEARCH HANDBOOK ON THE ECONOMICS OF PROPERTY LAW 148, 149 (Kenneth Ayotte & Henry E. Smith eds., 2011); Michael A. Heller, *The Boundaries of Private Property*, 108 YALE L. J. 1163, 1176-78 (1999); Francesco Parisi, *Entropy in Property*, 50 AM. J. COMP. L. 595 (2002).

4. *See* Henry E. Smith, *Property and Property Rules*, 79 N.Y.U. L. REV. 1719, 1732 (2004). *See generally* Calabresi & Melamed, *supra* note 2; Shyamkrishna Balganesh, *Demystifying the Right to Exclude: Of Property, Inviolability, and Automatic Injunctions*, 31 HARV. J. L. & PUB. POL'Y 593, 642, 643 (2008).

5. Kenneth Ayotte & Patrick Bolton, *Optimal Property Rights in Financial Contracting*, 24 REV. FIN. STUD. 3401 (2011). Among the costly activities to give notice, one can think of managing public registries, implementing doctrines like possession and apparent authority, or, in

stand in the way of a socially beneficial reallocation of resources, court enforcement of property rights may be denied or limited to damages, or the right may be subject to a (regulatory) taking.[6]

The technology of notice and enforcement has always had an important and duplicitous role in determining the optimal property-contract boundary.[7] On the one hand, at the state level, technology determines the optimal scope and design of property rights. Historically, for instance, the availability of real property registries made notice cheaper and expanded the list of sanctioned property rights; modern technology has had the same effect on personal property servitudes.[8] On the other hand, private parties also leverage technology to push the limits of contracts. Remotely-controlled kill switches, for instance, are commonly used by subprime car lenders to automatically and specifically enforce loan repayment.[9] To the same end, repos are used in financial contracting to obtain property-rule enforcement[10] and covenants that bind transferees can be employed to mimic a right in rem.[11]

In this Essay, we discuss the effects of the latest smart contract technology that allows for digital representation of contracts, distributed recording of transactions, and automatic enforcement of contract terms, on the property-contract boundary.[12] We make two claims. First, smart

ancient legal systems, celebrating conspicuous ceremonial transfers; see Hansmann & Kraakman, *Property, Contract, and Verification*, *supra* note 3; Carol M. Rose, *Possession as the Origin of Property*, 52 U. CHI. L. REV. 73 (1985); BARRY NICHOLAS, AN INTRODUCTION TO ROMAN LAW (1962).

6. Calabresi & Melamed, *supra* note 2; Parisi *supra* note 3; Naomi Lamoreaux, *The Mystery of Property Rights: A US Perspective*, 71 J. ECON. HIST. 275 (2011); Robert Rishwain, Comment, *Restrictive Covenants: Equitable Servitudes and Changing Conditions*, 2 SANTA CLARA LAW. 86 (1962) (documenting that in the beginning of the 20th century, as the Californian population grew and its economy evolved, courts denied enforcement of equitable servitudes when the use of property in an area had changed so much that enforcement would be oppressive and inequitable.); Danielle D'Onfro, *Contract-Wrapped Property*, 137 HARV. L. REV. 1058 (2024).

7. Hansmann & Kraakman, *Property, Contract, and Verification*, *supra* note 3, at S395-98.

8. Merrill & Smith, *supra* note 3, at 40-42; Susan F. French, *Design Proposal for the New Restatement of the Law of Property—Servitudes*, 21 U.C. DAVIS L. REV. 1213, 1225 (1988); D'Onfro, *supra* note 6, at 1127; Daniel Klerman & Stefan Bechtold, *Personal Property Servitudes Revisited*, 99 TUL. L. REV. 345 (2024). On the role of registries, see Abraham Bell & Gideon Parchomovsky, *Of Property and Information*, 116 COLUM. L. REV. 237 (2016).

9. Stacy-Ann Elvy, *The Vehicle Monitoring and Collection Technology Era*, 110 IOWA L. REV. 43 (2024).

10. Mark J. Roe, *Derivative and Repos in Bankruptcy*, in RESEARCH HANDBOOK ON CORPORATE BANKRUPTCY LAW 102 (Barry Adler, ed. 2000).

11. Morgan Ricks, *Organizational Law as Commitment Device*, 70 VAND. L. REV. 1303, 1317 (2017) ("The repurchase agreement or 'repo' transaction—ubiquitous in the financial sector—consists of the sale of a security coupled with a forward purchase of the same security at a slightly higher price. It is economically equivalent to a secured borrowing; the 'seller' (borrower) receives cash today and pays it back with interest on the maturity date. If the seller fails to make the required payment, the 'buyer' (lender) has the security as collateral. Practically speaking, the repo lender has a lien on the purchased security").

12. Much has been written about the fact that these features make contracts *smart*; for an overview, see Vimal Dwivedi et al., *Legally Enforceable Smart-Contract Languages*, 54 ACM COMPUT. SURV. 1 (2022). Smart contracts also alter the costs of writing complex contracts and

contracts have the potential to upset the distinction between property and contract by allowing parties to create "property *without* law", that is, a new form of de facto property rights that are freely customizable (ex ante) and potentially stronger (ex post) than traditional state-sanctioned property rights. This weakens state control over the use and enforcement of property rights. Second, smart contracts may lower the cost of notice and facilitate the ex post reallocation of rights, thereby expanding both the optimal scope for traditional property rights and state control over them.[13] Whether the end result is an increase or a decrease in social welfare will depend, as always, on how the technology will be deployed and regulated. Either way, property without law may change the way we understand property (and contract) in the digital world.

The mechanism through which a mere contractual right can become a de facto property right operates as follows. The primary contract is encoded in a software that runs on a blockchain platform tasked with tamper-proof record-keeping. The contract contains a substantive term and a covenant to bind transferees that obliges the primary buyer to include the substantive term in a subsequent contract with a secondary buyer. When the asset is transferred, automatic enforcement of the covenant is triggered, and the substantive term is included (again, automatically) in the next contract along with the covenant. This process repeats itself at any successive transfer. The contractual right runs then with the asset along the contractual chain as if it were a property right. Moreover, since enforcement is automatic, parties will not need to go to court in case of breach of the substantive term or the covenant and hence can, again, de facto contract for the property rule of specific performance.

In our framework of analysis, property law is the tie breaker between *incompatible* contracts.[14] If a seller sells the same right to two different buyers, the two contracts are incompatible as it is impossible to enforce both of them specifically. The main function of the law of property is to determine which of the two parties' rights is protected by a *property rule* and

hence may change the trade-offs involved in optimal contract design. *See* Alan Schwartz and Joel Watson, *The Law and Economics of Costly Contracting*, 20 J.L. ECON. & ORG. 2 (2004). Smart contracts may additionally provide for ways to make contracts renegotiation-proof. *See* RICHARD HOLDEN & ANUP MALANI, CAN BLOCKCHAIN SOLVE THE HOLD-UP PROBLEM IN CONTRACTS? (2021).

13. On the key role of public institutions in supporting traditional property rights, see Benito Arruñada, *Property as Sequential Exchange: The Forgotten Limits of Private Contract*, 13 J. OF INST. ECON. 753 (2017).

14. Hansmann & Kraakman, *Property, Contract, and Verification*, *supra* note 3, at S395-98; Ayotte & Bolton, *supra* note 5. In economics and finance, property is instead seen as a solution to *incomplete* contracts. *See* Sanford J. Grossman and Oliver D. Hart, *The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration*, 94 J. POL. ECON. 691 (1986). The two notions are not mutually exclusive. They provide two useful, but different, analytical tools.

will therefore be enforced via specific performance, while the other contractual right holder will receive (at best) damages.[15]

For example, a resale royalty right—artists' right to receive a percentage of the resale price of their copyrighted works at each successive transfer—is a property right in Europe, but not in the United States. Under the EU Resale Rights Directive, an artist enjoys a resale-royalty property right so that all successive buyers are bound by the artist's resale right, irrespective of the provisions in any of the contracts along the chain of transfers. Therefore, the resale right can be enforced against the final buyer, who will then be forced to pay royalties to the artist. Note that the law itself provides notice to buyers because the resale right is unwaivable and inalienable and hence burdens all artworks to which it applies.[16]

In the United States, an artist does not enjoy a statutory resale-royalty right, but could try to establish it contractually. The artist could add a resale-right clause in the primary-sale contract, possibly safeguarded by a covenant to bind transferees. However, the primary buyer may fail to pass the resale-right clause on to the next buyer, who would then not be bound by it; the only remedy available to the artist would be damages for nonperformance against the primary buyer. In this case, the contract between the artist and the primary buyer is incompatible with the contract between the primary buyer and the secondary buyer; American law resolves the conflict in favor of the secondary buyer.[17]

OpenSea, an American platform for the exchange of Non-Fungible Tokens (NFTs), offers a smart-contract version of the contractual workaround described above for resale rights on digital art. The advantage of the smart contract is that the enforcement of the covenant is automatic and hence it is impossible for the primary buyer—at least in theory, as we will appreciate—to breach the contract: resale-royalties flow automatically into the artist's digital wallet and the covenant is automatically included in each successive contract. Notice is served by the distributed ledger technology so that any transferee of the artwork can verify what rights run with it. This smart contract does not simply emulate the European resale-royalty right, it may go beyond it.

15. Incompatible contracts routinely arise in many other situations. Just to name a few examples: an agent may act *ultra vires*, an embezzler may sell the good to a good-faith buyer, a borrower may violate a negative covenant not to take on more debt, among other cases. *See* Hansmann & Kraakman, *Property, Contract and Verification*, *supra* note 3. *See also* Alan Schwartz & Robert E. Scott, *Rethinking the Laws of Good Faith Purchase*, 111 COLUM. L. REV. 1332 (2011); Giuseppe Dari-Mattiacci & Carmine Guerriero, *Law and Culture: A Theory of Comparative Variation in Bona Fide Purchase Rules*, 35 OXFORD J. LEGAL STUD. 543 (2015).

16. *See* Art. 1(1) of the EU Resale Rights Directive (Directive 2001/84/EC) of the European Parliament and of the Council of 27 September 2001 on the Resale Right for the Benefit of the Author of an Original Work of Art, 2001 O.J. (L 272) 32. On inalienability see Calabresi & Melamed, *supra* note 2. Most ordinary property rights are, instead, alienable and hence the notice function is generally served by an appropriate registration system.

17. *See also* Klerman & Bechtold, *supra* note 8, at 360-61.

The existence and inalienability of the resale right in Europe reflects public concern with the weak bargaining power of most artists and with inequality.[18] Ex ante, artists are thus prevented from customizing their resale rights by, for instance, waiving it or choosing a different percentage fee than the one set by law. In contrast, artists can do so with the smart contract, personalizing the property right to the specific interests of the parties. Ex post, courts control and can possibly modulate or deny enforcement in Europe, while enforcement of the smart contract happens automatically without court intervention. Through automatic enforcement, the resale-royalty right can be made run with the asset even in the United States, while being relieved of the limitations imposed by European law.

We proceed as follows. In Section I, we illustrate the three technological underpinnings of automatically enforced contracts: an infrastructure for verification of rights and notice to third parties; a consensus protocol for automatic enforcement; and a digital or digitalized asset. We emphasize the necessary conditions under which automatically enforced contracts operate and their vulnerabilities. In Section II, we illustrate the emergence of property without law in a diverse set of real-life cases: intellectual property, real estate, organizations, and financial contracts. These case studies are driven by available information on relevant implementations—some more detailed than others—and show how different applications may raise different issues in an assorted array of legal domains. In the discussion and conclusions, we delve into the theoretical implications of our analysis for the role of property law and the trade-offs that determine the boundary between property and contract, and offer some concluding remarks on the central question that surfaces from our analysis: is the emergence of property without law beneficial or detrimental for the legal system and society at large? Far from providing a final answer, we offer a framework to think about these issues.

I. The Technology of Property Without Law

Property without law requires three technological components. First, the *blockchain*, an infrastructure ensuring trustworthy and low-cost verification of rights, and providing reliable notice through distributed ledgers and a consensus protocol. Second, a *smart contract* that allows for automatic enforcement. Third, a *token*, a digital or digitalized asset that can be recorded on a digital ledger and circulated through a smart contract. In this section, we briefly introduce these three technologies.

18. *See* Recital 3 of the EU Resale Rights Directive, *supra* note 16 ("The resale right is intended to ensure that authors of graphic and plastic works of art share in the economic success of their original works of art. It helps to redress the balance between the economic situation of authors of graphic and plastic works of art and that of other creators who benefit from successive exploitations of their works.").

A. Distributed Ledgers and Consensus Protocols

Originating from the 2008 Bitcoin White Paper,[19] the Bitcoin blockchain addresses a classic double-spending problem—a seller selling the same asset to two different buyers—in a network of peer-to-peer transactions without a central third-party validator, such as a property register. Crucially, a consensus protocol enables participants to validate transactions by solving complex cryptographic puzzles, the so-called proof-of-work protocol.[20] Transactions are then permanently recorded in a distributed ledger that is accessible to all participants and nearly impossible to alter; and so, this system provides low-cost and reliable notice. The blockchain, however, is not entirely tamper-free. Due to errors or strategic behavior, different nodes may disagree on the transactions to be validated.[21] These disagreements may split the ledger into two incompatible chains of transaction, called hard forks, giving rise to two alternative digital realities with possible real-world ramifications. The possibility of forks, though considered a quintessential feature of the system, affects our conclusions to the extent that it creates uncertainty.[22]

B. Smart Contracts

Smart contracts were originally proposed as a theoretical possibility in 1997, predating the Blockchain.[23] However, it was not until the advent of the Ethereum blockchain protocol that smart contracts became practically operational.[24] Smart contracts are computer programs stored on a

19. Nakamoto Satoshi, *Bitcoin: A Peer-to-Peer Electronic Cash System*, (2008), https://bitcoin.org/bitcoin.pdf [https://perma.cc/LY8K-HJH5] (last visited Nov. 1, 2024).

20. In the past decade, many different blockchain protocols have entered the market for decentralized transaction validation. For a technical comparison, see Shijie Zhang & Jong-Hyouk Lee, *Analysis of the Main Consensus Protocols of Blockchain*, 6 ICT EXPRESS 93 (2020); Fahad Saleh, *Blockchain Without Waste: Proof-of-Stake*, 34 REV. FIN. STUD. 1156 (2021).

21. The most renowned example is the fork between "Ethereum" and "Ethereum Classic" after the DAO Attack in 2016. The DAO was a blockchain smart contract with open-source code that was supposed to act as a decentralized venture capitalist, where the holders of the DAO tokens would have voted on the project to undertake. The project raised $150 million. The DAO code had vulnerabilities that allowed some hackers to siphon one third of the funds. This signed the end of the DAO project but it also opened a discussion in the Ethereum community between those who wanted to forcefully revert the DAO attack and those who refused to roll back the history of blockchain transaction, claiming that it would have gone against the premises of the blockchain as an immutable technology. Robbie Morrison, Natasha C. H. L. Mazey & Stephen C. Wingreen, *The DAO Controversy: The Case for a New Species of Corporate Governance?*, 3 FRONTIERS IN BLOCKCHAIN 1 (2020).

22. Ben Abramowitz et al., *Democratic Forking: Choosing Sides with Social Choice*, *in* Proceedings of the International Conference on Algorithmic Decision Theory 341 (Nov. 2021).

23. Nick Szabo, *Formalizing and Securing Relationships on Public Networks*, 2 FIRST MONDAY 1 (1997). The idea to automatically enforce contracts predates even the conceptualization of smart contracts. For instance, in the copyright literature, it was already vibrant in the 90s with the debate around Digital Right Management. *See* Stefan Bechtold, *Digital Rights Management in the United States and Europe*, 52 AM. J. COMP. L. 323 (2004).

24. Vitalik Buterin, *Ethereum: A Next-Generation Smart Contract and Decentralized Application Platform* (2014), https://ethereum.org/content/whitepaper/whitepaper-

blockchain. Contractual obligations are encoded in a machine-readable form, following an "if *x* then *y*" logic, so that they can be automatically enforced. This system allows for a potentially infinite list of contingencies, specifying actions that will automatically follow the verification of predefined conditions.[25] Some contingencies can be automatically verified on-chain—think of a transfer of a digital asset or the passing of a deadline. Others—for instance, the price of gold—need to be verified off-chain, that is, in the real world, by a third-party data feed supplying the necessary off-chain information to the smart contract, the so-called "oracle" in blockchain jargon.[26]

C. Digital(ized) Assets and Tokenization

The third and possibly the most binding condition is that the asset can be transacted on chain. There are two broad categories of digital assets: (1) *native digital assets*, such as virtual currencies, digital art or governance tokens of a decentralized autonomous organization (DAO), and (2) *tokenized assets*, which are real-world assets, such as real estate or shares in a company, represented by a digital token. Making sure that a string of code effectively represents a piece of real-world property is all but straightforward.

Tokenization lacks a generally accepted operational definition, let alone a legal one. A recent report from the Bank for International Settlements defines tokenization as "the process of generating and recording a digital representation of traditional assets on a programmable platform, such as a distributed ledger."[27] The tokenization process is not standardized and is subject to considerable legal uncertainty and experimentation.[28]

The Unidroit Principles on Digital Assets and Private Law remain agnostic about the legal and operational technicalities of the tokenization process, stating that the Principles equally apply to both native and tokenized digital assets. The applicable (private) law of different jurisdictions determines if the link between the real-world asset and the digital

pdf/Ethereum_Whitepaper_-_Buterin_2014.pdf [https://perma.cc/S2YS-A8K7]. The key promise of the Etherum blockchain is to act as "the ultimate abstract foundational layer: a blockchain with a built-in Turing-complete programming language, allowing anyone to write smart contracts and decentralized applications where they can create their own arbitrary rules for ownership, transaction formats and state transition function." *Id.* at 13.

25. *See* Holden & Malani, *supra* note 12.

26. On the role and limitations of oracles, see Massimiliano Vatiero, *Smart Contracts vs Incomplete Contracts: A Transaction Cost Economics Viewpoint*, 46 COMPUT. L. & SEC. REV. 1, 5 (2022).

27. Bank for International Settlements, *Tokenisation in the Context of Money and Other Assets: Concepts and Implications for Central Banks* 6-7 (2024), https://www.bis.org/cpmi/publ/d225.htm [https://perma.cc/P5RD-G82S].

28. For a more specific analysis of US law on the matter, see Juliet M. Moringiello & Christopher K. Odinet, *The Property Law of Tokens*, 74 FLA. L. REV. 607 (2022).

asset is established in a legally binding way.[29] The state retains control over the extent to which parties can tokenize real-world assets, and regulatory competition may arise among different jurisdictions to attract asset tokenization.[30] For our analysis, we will focus on cases in which tokenization is practically feasible. We will offer comments on its limits after having illustrated some concrete cases.

II. Applications

Automatically enforced contracts are increasingly being used in a diverse set of real-life applications. In this section, we review some of them. While the most fitting example concerns resale rights for artists, there are other economically relevant implementations in real estate, organizations, and financial contracting.[31]

A. Intellectual Property Rights

American law does not give artists a (property) right on resale royalties.[32] In contrast, since the early 2000s, the European Directive on Resale Rights requires all EU member states to recognize a right to resale royalties for artists.[33] The Directive sets rates based on the sale price, starting at 4% of the resale price for sales up to €50.000 and decreasing progressively to 0.25% for the portion of the resale price exceeding €500.000 with a maximum cap for the royalties at €12.500.[34] The resale right applies to "original . . . works of graphic or plastic art such as pictures, collages, paintings,

29. UNIDROIT, PRINCIPLES ON DIGITAL ASSETS AND PRIVATE LAW 29 (2023) (Principle 4).

30. There are already early examples of this phenomenon. For instance, Liechtestein passed its Blockchain Act, called "Tokens and TT Service Providers Law," in 2020. The key building block of the Act is the so-called "Token Container Model" (TCM). Through the TCM, it is possible to 'load' the container with any right representing real assets. In other words, all rights can be legally tokenized under the law of Liechtenstein. All assets and rights can be represented by a token. Philipp Sandner, *Liechtenstein Blockchain Act: How Can Nearly Any Right and Therefore Any Asset Be Tokenized Based on the Token Container Model?*, MEDIUM (2019), https://philippsandner.medium.com/liechtenstein-blockchain-act-how-can-nearly-any-right-and-therefore-any-asset-be-tokenized-based-389fc9f039b1 [https://perma.cc/9F6A-GNG7]. Similarly, several U.S. states are trying to legislate on blockchain ahead of the federal government to try and attract blockchain investments. In the area of Decentralized Autonomous Organizations, see Pierluigi Matera, *Delaware's Dominance, Wyoming's Dare: New Challenge, Same Outcome?*, 27 FORDHAM J. CORP. & FIN. L. 73 (2022).

31. The amount of information available on each of these case studies differs as does the complexity of the underlying transaction. Therefore, our treatment may seem unbalanced in length. This should not be taken as mirroring the importance of each case.

32. Henry Hansmann & Marina Santilli, *Royalties for Artists versus Royalties for Authors and Composers*, 25 J. CULTURAL ECON. 259, 261 (2001).

33. Article 1(1) of the EU Resale Rights Directive, *supra* note 16: "Member States shall provide, for the benefit of the author of an original work of art, a resale right, to be defined as an inalienable right, which cannot be waived, even in advance, to receive a royalty based on the sale price obtained for any resale of the work, subsequent to the first transfer of the work by the author." *See also* Klerman & Bechtold, *supra* note 8, at 360-61.

34. Article 3(1) of the EU Resale Rights Directive, *supra* note 16.

drawings, engravings, prints, lithographs, sculptures, tapestries, ceramics, glassware and photograph," and includes copies of the work if they are made in limited numbers by the artists themselves or under their authority.

Thanks to blockchain technology, a piece of digital(ized) art can be encoded into a non-fungible token (NFT). The NFT is guaranteed to be unique, non-replicable and non-fungible by the very features of the blockchain technology and tokenization protocol used to create it. It can hence be sold and authenticated fully on-chain. When selling the token, the artist—or a specialized platform—can draft a specific smart contract that is digitally attached to the token. The contract can specify a resale right to be automatically triggered at each transfer, which must necessarily occur on the blockchain due to the digital nature of the asset. The royalty directly accrues to the artist's wallet, as specified in the smart contract. In addition, the smart contract can implement an automatically enforced covenant to bind transferees and hence make the (contractual) right to resale royalties run with the digital asset, just like a property right would.

An artist embedding a piece of art in an NFT can effectively replicate the resale royalty right available to artists in Europe for physical works of art, with the additional benefit of decreasing enforcement costs practically to zero. Indeed, opponents of resale-rights legislation point to high enforcement costs and the potential for forum shopping.[35] Differently from the European legislated solution, however, which grants an inalienable resale right, its digital equivalent is alienable and hence customizable, allowing the artist to set the royalty rate in response to market forces.[36]

There are several online platforms offering smart-contract templates for resale rights in NFT art. The rise, fall and comeback of OpenSea represents the most clear-cut and analytically interesting example.[37] OpenSea was the largest trading platform for NFTs during the NFT boom in 2021-22. It provided a standard smart contract for exchanging digital art tokens including royalties for secondary sales. The technology, however, failed to deliver on its promise.

A few months after its launch in 2021, it became clear that the system was vulnerable to a pernicious workaround. A buyer of the NFT could encode the NFT in a new token free of the initial resale clause and then sell the new token on an alternative platform allowing for zero-fee transfers. The automatic enforcement of the original resale-right clause was not triggered because the original token was technically not transferred; it was

35. Allison Schten, *No More Starving Artists: Why the Art Market Needs a Universal Artist Resale Royalty Right*, 7 NOTRE DAME J. INT'L COMP. L. 115, 127 (2017); Roland Kirstein & Dieter Schmidtchen, *Do Resale Royalties Make Artists Better-off? An Economic Analysis of a New EU Directive*, *in* LAW AND ECONOMICS IN CIVIL LAW COUNTRIES 257 (Bruno Deffains & Thierry Kurat eds., 2001); Hansmann & Santilli, *supra* note 32.

36. *See also* Klerman & Bechtold, *supra* note 8, at 360-63.

37. Ben Weiss, *The Rise and Fall of OpenSea*, THEVERGE (2024), https://www.theverge.com/24161573/opensea-crypto-nfts-workplace-rise-fall [https://perma.cc/E8JG-6ZGK].

simply boxed into a new one, which was then transferred. This problem, together with the decline of the NFT market and enforcement actions by the Securities and Exchange Commission, pushed OpenSea to stop collecting authors' royalties and sunset the smart contract in February 2024.[38]

In the meantime, a new technology was developed to cope with the problem, and a new ERC721-C protocol was launched at the end of 2023. Unlike its predecessor, the new protocol can filter the marketplaces in which the NFT can be sold and hence ban transactions on zero-fee platforms.[39] While it is too early to assess whether the new system will become a success and the current economic relevance of NFT for artworks may well be minimal, OpenSea's attempts show that using cleverly drafted smart contracts for digital asset transactions can create customizable de facto property rights that run with the asset without being legally sanctioned, thereby disposing of the need for and the control exercised ex post by court enforcement.

B. Real Property Rights

Ownership of real estate is heavily formalized, and transfers are recorded in publicly available registries for notice and verification purposes. The law limits the parties' ability to fragment ownership rights, allowing only few limited-use rights (real covenants, easements, and equitable servitudes) and fractional arrangements (such as the condominium).[40] Transaction costs and indivisibility make real estate a relatively illiquid asset class with prohibitive entry costs for many retail investors.

In the last decades, there have been various attempts to fractionalize economic interests in real estate through complex contractual and organizational arrangements, thereby boosting liquidity and ease of access.[41] On the ownership side, a common arrangement is the establishment of a fund organized as a Real Estate Investment Trust (REIT) owning a portfolio of real estate properties and offering investors shares or units of the fund. Fractional ownership in the fund effectively replicates fractional ownership of the property only with regard to economic rights. Management costs and minimum entry capital, however, remain high.[42] On the debt side,

38. Torey Akers, *NFT Marketplace OpenSea Ends Its Resale Royalty Policy, Sparking Industry-Wide Backlash*, THE ART NEWSPAPER (2023), https://www.theartnewspaper.com/2023/08/23/opensea-nft-marketplace-ending-resale-royalties-policy [https://perma.cc/HVZ8-U3TE].

39. Limit Break, *Introducing ERC721-C: A New Standard for Enforceable On-Chain Programmable Royalties*, MEDIUM (2023), https://medium.com/limit-break/introducing-erc721-c-a-new-standard-for-enforceable-on-chain-programmable-royalties-defaa127410 [https://perma.cc/JT4H-2DV2].

40. Hansmann & Kraakman, *Property, Contract, and Verification*, *supra* note 3.

41. Andrew Baum, Tokenization—The Future of Real Estate Investment?, 47 J. PORTFOLIO MGMT. 41 (2021).

42. For a detailed analysis of the legal construction and regulations underpinning REITS, see Jason S. Oh & Andrew Verstein, *A Theory of the REIT*, 133 YALE L.J. 755 (2023). For an

a widely-used technique is the securitization of mortgages that started in the 1990s and skyrocketed in the years leading up to the global financial crisis. Through a series of contractual and organizational arrangements, illiquid mortgages were turned into liquid securities.[43]

Smart contracts and tokenization have opened a new phase of experimentation of fractional economic interests in real estate. The basic mechanism is relatively straightforward: a real estate asset is owned by a legal vehicle—such as a fund or a limited liability company—in compliance with the formalities required by property law. The ownership interest in the vehicle is then tokenized, and the tokens are offered to investors. In its simplest instantiation, a real estate property is represented by a single NFT. The tokenization process ensures that the NFT legitimately represents the ownership interest in the asset. Therefore, circulating the NFT functionally transfers control and economic rights in the property. A well-known pioneering case is an NFT representing the ownership of a single house[44] in Columbia, South Carolina, which was transferred in October 2022 for $175,000.[45]

Another early example of real estate tokenization is Elevated Return, a New-York-based asset management company specializing in hospitality real estate. Elevated Return owns, among other properties, the St. Regis Aspen Resort, a luxury resort in Aspen, Colorado. In 2020, Elevated Return decided to sell a fraction of the equity interest in the resort issuing tokenized securities. To this end, it assigned part of the equity representing ownership of the resort to Aspen Digital, Inc., a Maryland corporation that was formed for this sole purpose.[46] Aspen Digital, Inc., issued "Aspen Coins," raising $18 million, equivalent to 19% of the equity interest in the resort.[47] The Aspen Coin is a security token exempted from SEC

analysis of the costs involved in REIT investment, see Timothy J. Riddiough & Jonathan A. Wiley, *Private Funds for Ordinary People: Fees, Flows, and Performance*, 57 J. FIN. & QUANTITATIVE ANALYSIS 3252 (2022).

43. For an early analysis of the legal structure of securitization, see Steven L. Schwarcz, *The Alchemy of Asset Securitization*, 1 STAN. J. L. BUS. & FIN. 133 (1994); Tamar Frankel, *Cross-Border Securitization: Without Law, but Not Lawless*, 8 DUKE J. COMP. & INT'L L. 255 (1997).

44. *Rectius*: the NFT representing the ownership interest of the limited liability company that formally owns the house.

45. Amy Rose Dobson, *Blockchain Makes Deeper Inroads into Real Estate as Roofstock Announces Its First NFT Home Sale*, FORBES (2022), https://www.forbes.com/sites/amydobson/2022/10/26/blockchain-makes-deeper-inroads-into-real-estate-as-roofstock-announces-its-first-nft-home-sale/ [https://perma.cc/6JAP-YXV5].

46. Aspen Coin, STOMARKET, https://stomarket.com/sto/aspencoin-st-regis-aspd [https://perma.cc/8EFT-Q7KW].

47. Home Key, *The Story of How a Hotel Was Tokenized, (And Why This Can Be Done With Any Real Estate)*, MEDIUM (2023), https://medium.com/@homekeytechnical/the-story-of-how-a-hotel-was-tokenized-and-why-this-can-be-done-with-any-real-estate-6706e35b09 [https://perma.cc/44VW-UCXY]. The issued tokens benefitted from the Regulation D (Reg D) (Rule 506(c)) exemption for registration of a company offering securities—which required they be offered only to 'accredited investors'—and hence, were privately sold on the crypto platform tZero to investors who passed the relevant know-your-customer (KYC) test.

registration.[48] It is traded on a secondary market available only to accredited investors. This construction effectively replicates a REIT on a blockchain, while arguably reducing transaction costs by cutting red tape and regulatory burdens.

A small perk attached to this deal unveils its potential. Aspen Digital, Inc., set up an "Aspen Digital Owner Benefit Program" available to holders of Aspen Coins.[49] Upon holding a predetermined amount of coins for 30 consecutive days, the holder automatically qualifies for a cash back program for the stay bill at the resort. Notably, the program needs no registration, and the benefit runs with the coin. Although not economically large, the program is an instructive example of the potential of the technology. Issuers could use the same mechanism to encode more salient benefits or burdens running with the token, thereby possibly making personal covenants a reality.

A growing industry is working on scalable tokenized real estate projects. RealT is a blockchain startup whose business model is to enable the tokenization of property.[50] The system is structured around a Series Limited Liability Company (SLLC) incorporated in Delaware.[51] An SLLC is a way to replicate the internal asset partitioning of a corporate group without having to set up different legal entities. Each series in the SLLC is treated as a separate legal vehicle—with its own assets, liabilities, ownership and management—which owns a single real estate asset.[52] Ownership is tokenized so that each series-specific token represents a partial property of that specific real estate asset.[53] The various properties are managed by a RealT property manager for a fee and are rented out. The rent is then distributed in Stablecoins proportionally to the tokens held.[54]

For our purposes, this construction presents two interesting aspects related to ownership circulation and pledgeability. Transferring a series-specific token effectively means circulating a piece of the fractional ownership of the real estate property. Consider a series of an SLLC owning a

48. 17 C.F.R. § 230.506(c).

49. AspenCoin, *Aspen Digital Owner Benefit Program* (2020), https://cdn.aspencoin.io/documents/Aspen%20Coin%20-%20Terms%20of%20Owner%20Benefit%20Program.pdf [https://perma.cc/A5YC-9LHH].

50. REAL TOKEN, *RealT - Legally Compliant Ownership of Tokenized Real Estate*, 2 (2019), https://realt.co/wp-content/uploads/2019/05/RealToken_White_Paper_US_v03.pdf [https://perma.cc/983J-5UTE].

51. On Delaware Series LLC, especially in relation to the legislative amendments introducing "registered series" used by RealT, see Norman M Powell, *Delaware Harmonizes Alternative Entity Series and UCC Article 9*, 76 BUS. LAW. 1141 (2020).

52. Bradley T. Borden & Mathews Vattamala, *Series LLCs in Real Estate Transactions*, 46 REAL PROP. TR. & EST. L. J. 255 (2011).

53. These are issued only to 'accredited investors' as the offering is not registered under the Securities Act 1993, instead exploiting the Reg D exemption. "Accredited investor" is defined at 17 C.F.R. § 230.501(a) (2023). RealT also benefits from Regulation S, for issuance to non-US persons. 17 C.F.R. § 230.90 (2023).

54. The stablecoin chosen for these operations is DAI. *See* https://makerdao.com/whitepaper/DaiDec17WP.pdf [https://perma.cc/Q4LX-FVBX].

single house and, in turn, imagine that the series' ownership is embedded in two tokens only, owned by A and B. Transferring a token from A to C is a quick and informal transaction, which effectively realizes the transfer of 50% of the property interest in the house. To understand the innovative element of this simple mechanism, it is useful to compare it with its off-chain analogue: a situation in which A and B are co-owners (tenants in common) of the house. The transfer of the partial ownership interest from A to C is still possible, but the transaction would be subject to the traditional formalities of property transfers, which can be time-consuming and costly. Moreover, tenants in common have a right to seek partition of the property, which makes the investment unstable and subject to potentially inefficient liquidation. In contrast, token holders do not enjoy that right because the property is legally undivided and held in full by the series in the SLLC. Therefore, tokenization adds a measure of capital lock-in to the investment.

Turning to pledgeability, the implications are potentially even more interesting. Consider the same shared-ownership situation described above. One of the co-owners (say, A) may want to use their share in the property as collateral for a loan. In the real world, mortgaging the property would require two essential steps. First the other co-owner, B, would have to explicitly agree to it, as a potential foreclosure by the creditor in case of default would have an adverse impact on B's rights. Second, as before, the mortgage would be subject to the costly formalities imposed by law, including registration. In contrast, a token mapping onto a partial ownership interest in the same house is quickly and inexpensively pledgeable in the public blockchain. To this end, RealT developed a specialized platform, allowing RealToken holders to leverage their (indirect) equity interest in real estate and easily borrow against their token while continuing to receive rental income.[55]

C. Organizations

Corporations are characterized by five defining features—agency, limited liability, entity shielding, capital lock-in, and transferability of shares (or other ownership instruments)[56]—that give the organization continuity and enable it to operate in the market—that is, to own property, enter into contracts, or stand in court—independently of its owners and

55. For the financial and technical functioning of the platform, see respectively *Understanding the Financial Mechanisms Related to Collateralization*, REAL TOKEN (Apr. 11, 2022), https://realt.co/understanding-the-financial-mechanisms-related-to-collateralization [https://perma.cc/2SZW-6MEZ]; *Understanding the Technical Mechanisms Related to RMM*, REAL TOKEN (Apr. 13, 2022), https://realt.co/understanding-the-technical-mechanisms-realted-to-rmm [https://perma.cc/22SU-K6S4].

56. REINIER KRAAKMAN, JOHN ARMOUR, PAUL DAVIES, LUCA ENRIQUES, HENRY HANSMANN, GERARD HERTIG, KLAUS HOPT, HIDEKI KANDA, MARIANA PARGENDLER, WOLF-GEORG RINGE & EDWARD ROCK, THE ANATOMY OF CORPORATE LAW, 1-29 (2017).

managers. Generally, these features cannot be achieved through contracts because they are proprietary in nature, that is, they can be enforced against third parties that come in contact with the entity.[57] Again, these proprietary features can be achieved at the price of costly formal requirements both at the incorporation stage and at various points over the life of the entity (think of issuing new shares or bonds, or going public).

One may wonder whether smart contracts can be used to mimic some or all of these features. In the crypto world, organizations created through smart contracts are known as Decentralized Autonomous Organizations (DAOs). In fact, blockchain technology coupled with a smart contract can realize capital lock-in and entity shielding without the recognition of the DAO as a legal entity.[58] Investors acquire DAO tokens, providing them with economic and/or voting rights as encoded in a smart contract. As token holders, the only action that investors can take is to transfer their tokens in the secondary market. It is not technically possible to force the liquidation of the DAO, as opposed to a traditional partnership at will. Thus, the DAO achieves capital lock-in. Similarly, a personal creditor of the token holder can obtain the sale of the token and attach the realization value of the sale. However, it cannot force the liquidation of the DAO. Hence, the DAO has strong entity shielding.[59]

Interestingly, a DAO cannot mimic limited liability as is not embedded in a recognized legal-entity form[60] and is commonly regarded as a partnership among the DAO token holders. This means that courts tend to hold token holders unlimitedly liable to business creditors beyond their initial contribution.[61] The smart contracts supporting DAOs create an asymmetric pattern for creditors' rights, whereby personal creditors of off-chain actors cannot attach the on-chain DAO assets, but on-chain creditors of the DAO can attach the off-chain assets of DAO token holders. This pattern is in stark contrast with established theoretical results and historical patterns: in the real off-chain world, limited liability is easier to mimic than entity shielding.[62] The opposite is true on-chain.[63]

57. Henry Hansmann & Reinier Kraakman, *The Essential Role of Organizational Law*, 110 YALE L.J. 387 (2000).

58. Oscar Borgogno & Edoardo D. Martino, *Decentralised Autonomous Organisations: Targeting the Potential beyond the Hype*, 16 L. INNOV. & TECHNOL. 392 (2024).

59. *See* LOON v. Department of Treasury, No. 1: 23-CV-312-RP (W.D. Tex. Aug. 17, 2023).

60. Chris Brummer & Rodrigo Seira, *Legal Wrappers and DAOs* (working paper, 2022), https://ssrn.com/abstract=4123737 [https://perma.cc/ES77-LTGT].

61. *See, e.g.*, United States District Court in Sarcuni v bZx DAO, No 22-cv-0618 (S.D. Cal. March 27, 2023).

62. Hansmann & Kraakman, *The Essential Role*, *supra* note 57.

63. Borgogno & Martino, *supra* note 58, at 39.

D. Financial Contracts

The traditional divide between property and contracts has become increasingly blurred in finance. A prime example of this trend is the introduction of bankruptcy safe harbors for financial collateral in the early 2000s.[64] These reforms of bankruptcy codes around the world made it possible to pledge financial assets as collateral without registration, and to keep them out of bankruptcy procedures, avoiding mandatory stay. This reform dramatically improved the liquidity of financial collaterals at the price of increasing systemic risk and externalizing losses to third parties. The application of smart contracts to financial assets has exacerbated this trend, allowing issuers and investors to create property-like entitlements on (digital) financial assets free of the traditional safeguards of property law and, in particular, notice. In the following, we look at tokenized long-term debt, tokenized deposits and tokenized collateral.

1. Tokenized Long-Term Debt

Borrowers can borrow long term from specific lenders through loan agreements or from the market through bonds. In both cases, creditors are exposed to the debtor's insolvency risk. To counter this risk, a lender has two main options, one based on contract and one based on property.

On the contract side, creditors can use covenants to allocate control rights to the creditor, contingent on the deterioration of the debtor's solvability. Including covenants in the indenture is often used as a renegotiation tool empowering the creditors.[65] Crucially, in case of a bankruptcy, the creditor is subject to mandatory stay and can only be satisfied within the bankruptcy procedure. Moreover, covenants do not run with the asset and are usually enforced through liability rules. For instance, if a covenant forbidding the debtor from selling specific assets (say, a machine) is breached, the creditor has no recourse against the third-party buyer and can only claim damages from the debtor.

Smart contracts have the potential to "propertize" covenants, making them automatically enforceable. Consider the earlier example of the machinery. If that covenant is encoded into a fully on-chain smart debt contract, the sale of the (token representing the) machinery can be made contingent on the approval of the original creditors. In this instance, the token cannot pass to the wallet of the third-party acquirer without such approval,

64. Philipp Paech, *The Value of Financial Market Insolvency Safe Harbours*, 36 OXFORD J. LEG. STUD. 855 (2016).

65. Clifford W. Smith, Jr. & Jerold B. Warner, *On Financial Contracting: An Analysis of Bond Covenants, 7* J. FIN. ECON. 117 (1979); Philippe Aghion & Patrick Bolton, *An Incomplete Contracts Approach to Financial Contracting*, 59 REV. ECON. STUD. 473 (1992); Michael R. Roberts, *The Role of Dynamic Renegotiation and Asymmetric Information in Financial Contracting*, 116 J. FIN ECON. 61 (2015).

as the transaction would not be validated. As with resale rights, this is technically possible.[66]

A property-law alternative to covenants are security interests established through specific procedures that require some form of notice and regulate the forceful sale of the collateral in case of foreclosure. In bankruptcy, collateralized creditors are subject to the mandatory stay, and the sale of the collateral may be subject to approval.[67] Security interests are property rights in that they run with the asset used as collateral. In past decades, we have witnessed a movement towards covenant-lite debt coupled with a massive use of collaterals.[68] Smart contracts have the potential to replicate security interests free from the control of the law the creation and foreclosure of security interests.[69]

Evidence from tokenized bonds registered according to securities law suggests that these large issuances are generally in line with off-chain practices. A tokenized bond entitles the token holder to receive the principal amount and interest at predetermined dates, just as the off-chain bondholder. However, on-chain enforcement of tokenized bonds is automatic, so that the security assets are automatically realized by the creditor upon verification of pre-determined conditions.

Unfortunately, our analysis of tokenized long-term debt must remain theoretical. Bond issuances that are exempted from registration and loans are not subject to disclosure requirements regarding the exact terms of the underlying smart contract. Therefore, it is challenging to assess whether, and to what extent, experimentation and innovation in this area are taking place.

2. Tokenized Deposits

When depositors question their bank's solvency, their best strategy is to "run" to withdraw their money before other depositors.[70] Bank runs destabilize the financial system. To minimize their occurrence, safety nets, such as deposit insurance and access to the central bank liquidity facilities[71] have been put in place to reduce depositors' risk and hence their incentive to engage in a run on the bank. Other safeguards become operational as

66. *See supra* Section II.A.

67. Kenneth Ayotte, *On the Mandatory Stay of Secured Creditors in Bankruptcy*, in RESEARCH HANDBOOK ON CORPORATE BANKRUPTCY LAW (Barry E. Adler ed., 2020).

68. Kenneth Ayotte & Patrick Bolton, *Covenant Lite Lending, Liquidity and Standardization of Financial Contracts*, in RESEARCH HANDBOOK ON THE ECONOMICS OF PROPERTY LAW 174 (Kenneth Ayotte & Henry E. Smith eds., 2011).

69. The mechanism underpinning this deformalization and some early real-world examples are detailed below. *See infra* II.D.3.

70. Douglas W. Diamond & Philip H. Dybvig, *Bank Runs, Deposit Insurance, and Liquidity*, 91 J. POL. ECON. 401 (1983).

71. Charles W. Calomiris & Eugene N. White, *The Origins of Federal Deposit Insurance*, *in* THE REGULATED ECONOMY: A HISTORICAL APPROACH TO POLITICAL ECONOMY 145 (Claudia Goldin & Gary D. Libecap eds., 1994).

the run starts and aim at slowing or stopping it. Examples of such measures include bank holidays and mandatory stay in bankruptcy. However, because of high financial and reputational costs, ex post solutions are rarely optimally and timely deployed. The speed of runs has increased in recent years, thanks to technology that facilitates online withdrawals and coordination on social media.[72]

Several banks are currently experimenting with tokenized deposits, often taking advantage of regulatory sandboxes.[73] The basic mechanism works as follows. The bank issues tokens representing deposit claims. The depositor is entitled to realize the claim at any time. The claim can be automatically liquidated on the blockchain, leaving the bank and the regulatory agencies with no tools to stop coordinated withdrawals. Although banks are still in the design phase of tokenized retail deposits,[74] there are already several ongoing experiments with wholesale deposits. For example, JP Morgan recently launched its permissioned blockchain to improve clearing and settlements among parties involved in their network through the JPM Coin.[75]

Counterintuitively, tokenized deposits could also provide banks and regulatory agencies with new tools to contain runs. For example, the Bank for International Settlements has recently proposed new forms of tokenized deposit contracts with early-withdrawal penalties so that early withdrawers would do no better than late ones during a run, thereby

72. J. Anthony Cookson, Corbin Fox, Javier Gil-Bazo, Juan Felipe Imbet & Juan Felipe Imbet, *Social Media as a Bank Run Catalyst* (Université Paris-Dauphine Rsch. Paper No. 4422754, 2023), https://www.ssrn.com/abstract=4422754 [https://perma.cc/TP5K-PAXD].

73. For an overview of the ongoing projects, see *Report on Tokenised Deposits*, EUROPEAN BANKING AUTHORITY 12-14 (2024), https://www.eba.europa.eu/sites/default/files/2024-12/4b294386-1235-463f-b9b5-08f255160435/Report%20on%20Tokenised%20deposits.pdf [https://perma.cc/5WW8-C4YQ].

74. Oliver Wyman & Onyx, *Deposit Tokens. A Foundation for Stable Digital Money* (2023), https://www.oliverwyman.com/content/dam/oliver-wyman/v2/publications/2023/feb/oliver-wyman-jp--morgan-deposit-tokens-report-final.pdf [https://perma.cc/GQ34-LZ98].

75. JPM Coin was announced in February 2019 and launched in late 2020. In October 2023, JPM Coin was reportedly used to handle 1 billion $ in daily transactions. *See* PYMNTS.com, *JPMorgan: JPM Coin Handles $1 Billion in Daily Transactions*, (2023), https://www.pymnts.com/blockchain/2023/jpmorgan-jpm-coin-handles-1-billion-dollars-daily-transactions [https://perma.cc/7RA2-HKV5]. In November 2023, Onyx by JP Morgan announced that the project started to include payment programmability. *See* Ledger Insights, *Siemens Is First JP Morgan Client to Use JPM Coin Programmable Payments* (2023), https://www.ledgerinsights.com/jp-morgan-programmable-jpm-coin-payments [https://perma.cc/E552-AD8R]. JP Morgan official reported that the inclusion of the programmability features increased adoption dramatically: "We've seen the number of transactions explode by factors of ten, if not hundreds." *JP Morgan Says JPM Coin Transactions Have "exploded" Because of Programmability*, LEDGER INSIGHTS (2024), https://www.ledgerinsights.com/jp-morgan-says-jpm-coin-transactions-have-exploded-because-of-programmability [https://perma.cc/VJM9-D3FC]. In May 2024, it was announced that JPM coin would be as the settlement mechanism for Broadridge's DLR (Distributed Ledger Repo) platform. See Douglas Blakey, *JP Morgan's JPM Coin Announced as the Settlement Mechanism for Broadridge's DLR Platform*, YAHOO FINANCE (2024), https://finance.yahoo.com/news/jp-morgan-jpm-coin-announced-225735256.html [https://perma.cc/552J-ES4Q].

eliminating the incentives to participate in a bank run.[76] This would require a robust regulatory intervention whereby national authorities would require all banks tokenizing deposits to include additional strings of code in the smart contract to limit uncontrolled withdrawals.[77] In this way, (permissioned) blockchain applications on bank deposits, coupled with effective ex ante regulation, may even limit runs, disrupting the incentives to coordinate. Automated enforcement may thus provide novel tools to limit bank runs.

3. Tokenized Collateral

The availability of high-quality collaterals and the ability to realize them upon default provides financial assets with safety and liquidity.[78] According to the Unidroit Principles on Digital Assets and Private Law, digital assets can be used as collateral and hence be subject to security rights.[79] Such rights have third-party effects if the party taking security has control over the digital asset.[80] Establishing a security right on a token mimics a security right on the underlying asset, but it is subject to far laxer control. This construction underlines how the nature of tokenized digital assets is prone to deformalize the traditional property doctrines on security rights, fostering an ongoing trend in the financial industry in recent decades.

To facilitate collateralization, JP Morgan launched its "Tokenized Collateral Network" (TCN) via Onyx, its permissioned blockchain network. The current level of disclosure of the TCN is low in terms of deals and encoded terms. However, the public information available aligns with our thesis: smart contracts can be used to create *de facto* property rights, in this case, security rights. On its website, Onyx promises that the TCN provides an "application enabling investors to utilize assets as collateral. Transfer collateral ownership without moving assets in underlying ledgers

76. Bank for International Settlements, *Blueprint for the Future Monetary System: Improving the Old, Enabling the New*, *in* BIS ANN. ECON. REP. 86, 99-100 (2023). For a discussion of a similar construction, with specific reference to the US, see Hilary J. Allen, *Digital Bank Holidays*, 41 YALE J. REGUL. 856 (2024).

77. One possible way to do so is to imposed redemption charges upon large withdrawals, as proposed by Edoardo D. Martino & Enrico Perotti, *Containing Runs on Solvent Banks: Prioritising Recovery over Resolution*, 7 J. FIN. CRISES 1, 9 (2025).

78. Gary Gorton & Guillermo Ordoñez, *The Supply and Demand for Safe Assets*, 125 J. MONET. ECON. 132 (2022).

79. *See* UNIDROIT, *supra* note 29, at 95 (secured transactions).

80. Establishing a security right on the token that mimics a security right on the underlying asset. *Id.* at 100 (principle 15). In Principle 6, control is defined as: "(i) the exclusive ability to prevent others from obtaining substantially all of the benefit from the digital asset; (ii) the ability to obtain substantially all of the benefit from the digital asset; and (iii) the exclusive ability to transfer [these] abilities . . . to another person." *Id.* at 51. In the commentary, the Principles underline that 'control' in the context of digital assets is a purely factual matter that gives rise to legal consequences, including third-party efficacy. *Id.* at 51-54.

— while remaining invested" and that it "provides added capabilities for assets previously unavailable for use as collateral."[81]

In June 2024, CoinDesk reported that Fidelity International had joined the network by tokenizing one of its money market funds.[82] After the public announcement of this deal, one of the executives of Onyx stated that: "Fidelity's participation in TCN brings its MMF units onto our network through tokenization, adding a new asset that is otherwise prohibitively complex to use across today's collateral landscape."[83] This exemplifies the potential of smart contracts and tokenization to increase the array of assets that can be collateralized and improve collateral mobility, without being bound by legal formalities.

Discussion and Conclusions

In this Essay, we posit that smart contracts have largely untapped potential to create property rights without legal backing and legal restraints. The question then is whether this potential is socially advantageous. The restrictions imposed by law on traditional property rights are the result of an important balance between the benefits of more contingent rights and the costs of notice and enforcement.[84] Decentralized ledger technology has reduced verification costs, arguably to a minimum, while smart contracting technology has cut the costs of enforcement. After these changes, has the optimal boundary between contract and property shifted, expanding the realm of property rights? Far from providing a final answer to these questions, we take stock of our case studies and offer a framework to think about these issues.

Scholars have advanced three main justifications for the *numerus clausus* doctrine that restricts the number of sanctioned property rights. We build on these contributions and show how property without law shifts the tradeoffs they identify. The first justification focuses on verification costs for third parties, who need to verify which rights encumber the asset. To enable verification, the state supports a notice system made of rules, procedures, and registries.[85] From this perspective, the blockchain ledgers that record transactions on digital assets constitute a much cheaper notice system than traditional state institutions and, hence, they enlarge the optimal domain of property rights.

81. *Tokenized Collateral Network*, J.P. MORGAN, https://www.jpmorgan.com/onyx/tokenized-collateral-network [https://perma.cc/4548-5DX3].

82. Ian Allison, *Fidelity International Tokenizes Money Market Fund on JPMorgan's Blockchain*, COINDESK (2024), https://www.coindesk.com/business/2024/06/10/fidelity-international-tokenizes-money-market-fund-on-jpmorgans-blockchain [https://perma.cc/4DDD-83E4].

83. *Id.*

84. Hansmann & Kraakman, *Property Contract and Verification*, *supra* note 3.

85. *Id.*

Tokenization, however, turns promises into assets without legal sanctioning, as did many financial innovations—from promissory notes to derivatives—with legal backing.[86] The problem is that, without law, there is no binding obligation to serve notice to third parties;[87] history suggests that this creates potential for abuse and may require regulation. In addition, the "technical transparency" of blockchain transactions often results in operational uncertainty with regards to the contracting parties, because of the anonymity of transactions. In the real world, it is often necessary to identify rightsholders—think of taxation—making anonymity a potential problem.

A second justification maintains that the *numerus clausus* serves a standardization purpose, so that those who come in contact with assets have lower information costs—that is, lower costs of distinguishing among different property rights.[88] From this perspective, is not clear whether the optimal boundary has shifted as smart contracts do not reduce the costs for private parties to process and understand the relevant information.[89]

A third justification suggests that the *numerus clausus* counters a natural process of fragmentation of rights. While it is easy to divide property into pieces and sell them to different individuals, it is much harder to buy each piece back to recompose the whole. De-fragmentation may be necessary when the optimal use of the property has changed, but could be impracticable because each fragment-holder can exercise a de facto veto power on reunification. As it is easier to fragment rights than to reassemble them, any system that enables the unlimited arrangement and splitting of entitlements runs the risk of impeding efficient re-assembly in the long term. An additional problem with fragmentation is that, as evidenced by the securitization of mortgages, fragmentation of property rights dilutes the incentives to monitor (the debtor, in that case).[90] A state-run system of property rights that limits the freedom of parties to re-arrange and split up entitlements reduces this risk.[91]

The same view justifies ex post judicial control over the remedies awarded in case of breach. While property rules (injunctions and specific performance) reinforce the fragmentation process because they uphold the rights of partial owners, liability rules (damages) may favor reunification,

86. KATARINA PISTOR, THE CODE OF CAPITAL HOW THE LAW CREATES WEALTH AND INEQUALITY (2019).

87. See also our discussion of authors' resale rights in the Introduction and *supra* Part II.A. Recall also that even "with law," notice of property rights is not always guaranteed by formal property registry and it is often guaranteed by other legal institutions, such as possession—see for instance property rights on chattels.

88. Merrill & Smith, *supra* note 3.

89. See also our discussion of DAOs in *supra* Part II.C.

90. Jung-Hyun Ahn & Régis Breton, *Securitization, Competition and Monitoring*, 40 J. BANKING & FIN. 195 (2014). See also our discussion of real-estate tokenization in *supra* Part II.B.

91. *See* Parisi, *supra* note 3. On the related anticommons concept, see Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets*, 111 HARV. L. REV. 621 (1998).

because they allow third party buyers to force a sale of partial rights, in a way that is not too dissimilar from a taking.[92] Since automatic enforcement disposes of courts, it may also remove valuable ex post reunification mechanisms.

These considerations point to the need to rethink the regulatory framework surrounding property rights and move from traditional forms of ex ante and ex post regulation of property rights to novel and *smarter* forms of regulation[93] that leverage, rather than counter, new technologies. As an example, consider our discussion of tokenized deposit, we have stressed that smart contracts may make it easier for investors to cause a bank run, but that smartly regulated tokenized deposits may include computer code that slows down such runs.[94]

In addition to reducing the cost of notice, smart contracts reduce two additional contracting costs: the costs of making contracts more contingent and the costs of enforcing such contingencies. One of the main obstacles to contingent contracts is the non-contractibility of certain contract terms, such as a promise not to renegotiate the contract at a later time.[95] Similarly, another obstacle is the practical unenforceability of certain (contractible) terms, such as an inverse warranty that gives the seller of an asset of uncertain value the right to an additional payment should the asset turn out to be a "gem." Here the problem is not that the term is not contractible, but rather that it is practically cumbersome for the buyer to track the value of the asset post sale and trigger the clause.[96] Smart contracts may offer ways to address both types of problems and hence make contractual and de facto property rights more specific and hence more efficient.

Some readers may rightfully contend that smart contracts are not immune from technological and legal challenges. The technology supporting smart contracts is indeed far from perfect. There have been many instances in which hacks or technical failures have generated forks on the blockchain, creating two alternative digital realities that needed ex post and ad hoc reconciliation by blockchain communities with dubious legitimacy.[97] Furthermore, blockchain systems are under scrutiny as to their environmental impact.[98] Even when smart contracts systems work as intended,

92. Parisi, *supra* note 3. *See also* Boudewijn Bouckaert & Gerrit De Geest, *Private Takings, Private Taxes, Private Compulsory Services: The Economic Doctrine of Quasi Contracts*, 15 INT'L REV. L. & ECON. 463 (1995).

93. Smart regulation follows in the steps of IAN AYRES & JOHN BRAITHWAITE, RESPONSIVE REGULATION: TRANSCENDING THE DEREGULATION DEBATE (1992).

94. *See supra* Part II.D.2.

95. *See* Holden & Malani, *supra* note 12.

96. Inverse warranties are used sporadically and make take various forms, from resale rights to earnouts. *See* Giuseppe Dari-Mattiacci, Sander Onderstal & Francesco Parisi, *Asymmetric Solutions to Asymmetric Information Problems*, 66 INT'L REV. L. & ECON. 1 (2021).

97. The most paradigmatic example is the hack of the DAO in 2016. *See supra* note 21.

98. The problem specifically relates to proof-of-work protocols, such as the Bitcoin one. For an overview of the debate and findings, see Moritz Wendl, My Hanh Doan & Remmer Sassen,

creative users may be able to outsmart them, as it happened to OpenSea's first attempt to offer artist resale rights. We are still in an experimentation phase and, as OpenSea showed, operators are still learning from their mistakes.[99]

How smart contracts will interact with existing legal systems is yet to be seen. As smart contracts are applied to tokenized real assets (such as real estate), court cases concerning the underlying assets may have an impact on the rights and obligations of the token owners.[100] There are only a few court cases adjudicating issues related to smart contracts. In part, this is by design: automatic enforcement is meant to avoid ex post court involvement. At a minimum, the smart contract changes the path of possible future litigation. While in a traditional contract, the promisee is the plaintiff in a potential lawsuit for non-performance, in a smart contract it is the promisor who may end up suing to contest the automatic enforcement of the promise, which in turn changes the parties' ex post bargaining position, reallocates insolvency risks, and possibly redistributes litigation costs, with important practical consequences.

A general implication of our analysis is that smart contracts may turn the traditional freedom of contract into a "freedom of property," effectively allowing contractual parties to bind non-contracting parties beyond the *numerus clausus* of state-sanctioned property rights. The contrast between the OpenSea resale rights smart contract and the European legislation illustrates this point: while European legislation imposes the same rule to all artists, the smart-contract solution allows for customization and, in a sense, personalization of property rights to the needs of the individual artist.[101] Smart contracts also allow for the creation of property rights when the law does not provide for one, such as entity shielding for DAOs, and for the (possibly inefficient) fragmentation of existing unitary rights, as we have seen with tokenized real estate.[102]

Yet, while technology may enable private parties to create and enforce property-like rights, the state will still be needed to fill loopholes in enforcement and to restrict undesirable abuses of property without law. Legal domains die hard. This is especially true of property.

The Environmental Impact of Cryptocurrencies Using Proof of Work and Proof of Stake Consensus Algorithms: A Systematic Review, 326 J. ENVTL. MGMT. 116530 (2023).

99. *See supra* Part II.A.

100. Juliet M. Moringiello & Christopher K. Odinet, *The Property Law of Tokens*, 74 FLA. L. REV. 613 (2022).

101. *See supra* Part II.A. There is a growing literature on personalization of law, starting with Omri Ben-Shahar & Ariel Porat, PERSONALIZED LAW. DIFFERENT RULES FOR DIFFERENT PEOPLE (2020). The literature makes the point that the law should be more personalized to individual characteristics now that data is available more cheaply and widely. The point we make here concerns a decentralized personalization of property rights, without the involvement of the state.

102. *See supra* Part II.B.