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Tokenization and Regulatory Compliance for Art and Collectibles Markets: From Regulators' Demands for Transparency to Investors' Demands for Privacy

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Introduction

Thanks to the Internet, individuals and organizations can exchange digital information without centralized intermediaries or trusted third parties. *Distributed ledger technology* (DLT) and related innovations augment the Internet's potential; hence, it is now possible to transfer economic value, rights, and claims without a custodial intermediary such as a bank, financial institution, or stock exchange (Tapscott & Tapscott, 2018).

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This new form of peer-to-peer economic exchange is accomplished via *tokenization*.

Tokenization allows people to trade via a distributed ledger a variety of ownership and access claims, licenses, and royalty rights as an alternative to conventional, paper-based exchange (Sunyaev et al., 2021). Tokenized claims can pertain to both physical and digital assets. Investors can trade tokenized claims to physical assets such as real estate, artworks, antique furniture, vintage cars, race horses, historical instruments, rare books, collectibles, customized machinery, and limited-edition fashion items (Whitaker & Kräussl, 2020). Investors, likewise, can trade tokenized claims to purely digital artworks like Beeple's "Everydays—The First 5000 Days" (sold by Christie's auction house for USD $69.3 million) or "The Pixel" by Pak (sold by Sotheby's auction house for USD $1.4 million) (ArtReview, 2021; Reyburn, 2021).

The tokenization trend began when Ethereum—a distributed ledger that is both public and permissionless—introduced support for general programming logic (Sunyaev et al., 2021). There are now broadly accepted standards such as Ethereum's ERC-20 for *fungible tokens*, ERC-721 for *non-fungible tokens* (NFTs), and ERC-1155 for either fungible or non-fungible tokens. ERC-20 tokens, alongside Bitcoin (BTC), are largely responsible for the popularity of fungible cryptocurrencies. NFTs, by contrast, each represent a unique instantiation of value; hence, NFTs are especially useful for claims that pertain to singular physical or digital objects, limited-edition products with unique serial numbers, and custom-made items (Whitaker, 2019).

The transfer of a token—either fungible or non-fungible—is achieved when a new record is appended to a distributed ledger's transaction history. Transactions typically contain details such as the wallet addresses of senders and receivers, the tokens that are transferred, and the transaction type. *Privacy-preserving* DLT solutions can purposefully omit transaction details from a publicly viewable ledger, either in entirety or in part. They aim to prevent the collection of identity information about the holders of particular wallets (Androulaki et al., 2020).

The privacy-preserving exchange of tokenized claims is potentially of interest to art and collectibles investors, who rely on high levels of discretion (Day, 2014); but for tokenized claims to become useful within

regulated markets, additional documentation is required to identify market participants. Simply put, tokenized claims must comply with Anti-Money Laundering (AML), Counter-Financing of Terrorism (CFT), and Know Your Customer (KYC) laws. Europe's Fifth Anti-Money Laundering Directive (5AMLD) is especially pertinent, since it demands identification information and due diligence checks from art intermediaries. An array of digital document or certificate formats can be used for identification purposes, but to comply with laws such as Europe's General Data Protection Regulation (GDPR), natural persons' identity information must not be stored on a public ledger. If tokenized claims' transaction details or information about assets' permanent attributes is meant to be publicly viewable, then they can be stored *on-chain*, but natural persons' identity information must be stored *off-chain*.

Tokenized claims for digital art and collectibles achieved prominence in late 2017, when Dapper Labs' CryptoKitties became so popular that they congested the global Ethereum network. In 2021, tokenized claims for physical artworks gained attention. The family of Wladimir Baranoff-Rossiné (1888–1944) sold some of his artworks via Mintable, and the British artist Damien Hirst sold 10,000 unique physical artworks via Palm (Sullivan, 2021; Tarmy, 2021).

Tokenization offers art and collectibles investors a new way to achieve *fractional ownership* (Whitaker & Kräussl, 2020). The most common way, at present, for investors to achieve fractional ownership of high-value artworks is to purchase comparatively low-value shares of a securitized art fund. Liquid shares purchased on a secondary market thus provide an alternative to the primary art market's low liquidity. Tokenized fractional ownership extends this concept to a global pool of investors who can access a public ledger like Ethereum, so that investors are no longer obliged to register with a custodial broker or a company-owned stock exchange. There is, however, an important caveat. Regulatory developments are required to build a bridge between tokenized claims and custodied physical assets, so that the tokenized claims are legally binding and assets' custodians are liable in various jurisdictions.

In this chapter, we first compare two options for the fractional ownership of physical artworks and collectibles: securitized fractions traded via a company-owned exchange, and tokenized fractions traded via a global,

public ledger. We then acknowledge the tension between regulators' demands for transparency and auditability and art investors' demands for privacy. We discuss regulatory requirements that pertain to the identification of art market participants and the storage of natural persons' identity information; then, in response, we encourage further research into digital certificates (stored off-chain), used in combination with *zero-knowledge proofs* (ZKPs) for selective disclosure. In sum, we endorse the prospective use of a *technology stack* for physical artworks and collectibles—a work-in-progress that combines DLT for tokenized claims and fractional ownership, off-chain identity information for regulatory compliance, and ZKPs for selective disclosure.

Tokenization for Fractional Ownership, Collateral, and Sponsorship

In 2020, demand for the fractional ownership of artworks and other luxury assets increased dramatically. Masterworks and Acquicent are notable examples. Masterworks attracted 10,000 new investors per month, and Acquicent enjoyed an 80% increase in sign-ups by potential investors (Kazakina, 2020).

Fractional ownership, acquired via secondary markets, is an alternative to the primary art market's high fees and low liquidity. The fee problems are caused by the fragility of the physical assets and the complicated acquisition and exchange processes (Campbell, 2008; Day, 2014). Between a buyer and a seller are dealers, auction houses, and gallerists who profit from high transaction costs. The buyer's premium charged by Christie's auction house, for instance, falls anywhere between 14.5% and 30.5%, depending on the location of the auction (Christie's Auction House, 2020).

Specific options for fractional ownership include shares of a single artwork, shares of an art fund, tokenized fractions of a single artwork, and tokenized fractions of an index fund. Fractional ownership—accomplished via shares or tokens—allows investors to participate in art markets without having to transport, store, or care for physical assets, and it

enables investors who cannot afford high-value artworks to instead purchase comparatively low-value assets, namely the shares or tokens (Whitaker & Kräussl, 2020). Well-known Real Estate Investment Trusts (REITs) appeal to investors for similar reasons: investors do not have to act as caretakers for a particular property, they can acquire fractional ownership of a diversified property portfolio, and they can conveniently purchase and sell liquid shares of the REIT via online brokerage platforms.

Thanks to fractional ownership, the secondary art fund market, valued at an estimated USD $1 billion, has better liquidity than the primary art market, which is roughly valued at USD $60 billion (Deloitte, 2017). The art fund market dates to at least 1904, but it did not achieve prominence until the 1970s when the British Rail Pension Fund invested in artworks (Maneker, 2021b; Velthuis & Coslor, 2012). The Artemundi Global Fund is a recent financial success, for which transparent pricing data exists. From 2010 until 2015 (the fund's final year), the Artemundi Global Fund generated an average net annual return of 17% (Gylfason, 2020).

As for the fractional ownership of a single artwork, Masterworks already offers this option to investors. Masterworks' online platform allows art investors to build portfolios of shares and to then sell their shares on a secondary market created by the Masterworks' company-owned exchange. An art investment company named Maecenas revised this concept and used a DLT-based exchange instead of a company-owned exchange. Maecenas splits high-value artworks into tokenized fractions, using the ERC-20 fungible token standard. Buying a tokenized fraction of a single artwork (created via Maecenas) is thus comparable to buying a securitized fraction of a single artwork (created via Masterworks).

A non-custodial, Ethereum-based platform named NFTX extends this concept further. NFTX allows collectors of tokenized artworks and collectibles to create a tokenized index fund. The tokenized index fund is akin to a securitized art fund, but it is DLT-based. Fractions of the tokenized index fund created via NFTX can then be traded on non-custodial, Ethereum-based exchanges like Uniswap. The index fund tokens can also be staked via the NFTX platform to generate yield in the form of Ethereum's native currency (ETH). This is a genuinely new revenue stream for art investors.

Securitization and tokenization are similar in principle, but as noted, the medium of storage and exchange differs for each. Shares are registered on a proprietary exchange like the Nasdaq Stock Market (owned by Nasdaq, Inc.), whereas asset tokens are usually registered on an "unincorporated" distributed ledger (Zetzsche et al., 2017). If art investors purchase tokenized fractions instead of securitized fractions, they can purchase tokens directly from an asset's custodian, without necessarily requiring a brokerage or a company-owned exchange, and the transaction typically settles within minutes instead of days. By digitizing securitization's paper trail, tokenization reduces transaction costs (Sunyaev et al., 2021). This is a notable economic advantage.

Fractional ownership via secondary markets is not the only way to address the primary art market's lack of liquidity. Investors like Michael Steinhardt and Steven A. Cohen pledged artworks as collateral for loans of liquid cash from financial institutions. In 2011, Steinhardt nominated 20 paintings and drawings—some by Pablo Picasso and Jackson Pollock—as collateral for a loan from the JP Morgan Chase Bank (Weiss & Kazakina, 2011). Cohen entered into a similar agreement with Morgan Stanley at the end of 2015 (Goldstein, 2016). Since the volatility of blue-chip artworks is considered low, art-backed loans can secure low interest rates (Maneker, 2021b). An online, company-owned platform named NFTfi extended this concept of art as collateral to NFT-collateralized loans of fungible cryptocurrencies. The concept of art as collateral can potentially be extended to NFT-collateralized loans of cash from traditional financial institutions as well (Morante & Sofge, 2021).

In addition to benefits for investors, tokenization offers a potential advantage for artists and creators of collectibles, namely the ability to determine the resale conditions for their work and automatically receive portions of their work's resale values. At present, artists receive a portion of their work's initial sale value (together with galleries and auction houses), whereas they do not usually receive any profits from their work's resale events (O'Dair, 2019; cf. Maneker, 2021a). Artists' experiments with ledger entries and transaction conditions can be traced to Yves Klein's "Zones of Immaterial Pictorial Sensibility" from 1962 (Vikram, 2021).

A tokenized work's resale conditions can also be altered to suit artists' early sponsors or patrons, so that they too receive a portion of resale values via automated payments (Whitaker & Kräussl, 2020). Some people participate in art markets for reasons of aesthetic appreciation, emotional attachment, or moral support more so than investors' usual pecuniary concerns (Frey & Eichenberger, 1995; Gylfason, 2020). Tokenization thus offers sponsors, patrons, and supporters of art the prospect of permanent association—even pseudonymous association, if they wish—with artworks or art collections. It remains to be seen if this notion of *tokenized sponsorship* proves successful in comparison with the economic motives of increased liquidity and transaction-cost improvements.

For art and collectibles markets, tokenization entails not only benefits but challenges as well (O'Dair, 2019). For many of the technical challenges, there are experimental or nascent solutions. Excessive energy consumption, for example, is only an issue for a subset of distributed ledgers (Sedlmeir et al., 2020), and the performance of public ledgers like Ethereum can be improved via layer-2 solutions like *zk-rollups*, which allow for thousands of complex transactions per second (Schaffner, 2021). Privacy requirements are a more sensitive, ongoing challenge for DLT, especially for public ledgers (Platt et al., 2021; Preukschat & Reed, 2021).

If regulation requires participants in art and collectibles markets to register detailed transaction information on a public ledger, this might alienate investors that value discretion (Day, 2014; Oosterlinck, 2017). Discretion and anonymity are crucial for art investors, dealers, and auctioneers. So, too, is privatized knowledge. It enables investors to barter for the best deals, and it allows intermediaries, firstly, to protect key clients from competitors, and, secondly, to capitalize on research and insights about a given artefact and its market value to determine a margin between the acquisition price and the sale price. Private, interpersonal relationships and discretion are thus the heart and soul of the art market, not publicly viewable identity information and due diligence checks (Day, 2014; Runhovde, 2021). The tension is palpable.

Tokenized Claims for Custodied and Non-custodied Assets

Tokenized ownership, sponsorship, and access claims inspired a flurry of innovation in art markets and creative industries (O'Dair, 2019; Whitaker, 2019); but the liability of custodians that sell tokenized ownership claims is a complicated matter. This is in line with the ambiguous legal status of many DLT-based innovations (Zetzsche et al., 2017). Tokenized claims can pertain to digital artworks or physical artworks; they can be fungible (for fractional ownership of an artwork) or non-fungible (for complete ownership of an artwork); and they can pertain to custodied assets or else assets without a custodian. For investors interested in physical art and collectibles, only tokenized claims about custodied assets are relevant, whereas for investors interested in digital art and collectibles, both custodied assets (stored on a third-party server) and non-custodied assets (stored on-chain or on individuals' devices) are relevant.

If an investor purchases a tokenized ownership claim (NFT) for a digital artwork that is stored fully on-chain, then there is a direct link between the tokenized claim and the artwork's essential content. A conventional intermediary is not required to enforce the link between the claim and the asset. Although this level of control is desirable for some investors, the storage of large media files on a distributed ledger is expensive and impractical; hence, it is rare to find digital art stored fully on-chain. The Autoglyphs collection by Larva Labs is a notable exception. On 10 June 2021, Sotheby's auction house sold "Autoglyph #177" for USD $201,600 (Konrad, 2021). Autoglyph NFTs contain publicly viewable hex data plus instructions about how to render the hex data as a glyph image. This means that the artwork does not have to be stored off-chain as a high-resolution image file. The code that generates the glyph image is stored directly on-chain; hence, an Autoglyph NFT, as the name implies, is self-enclosed.

If a digital artwork exists as an image file stored off-chain, then the tokenized claim typically includes a link to the file's location and/or a cryptographic hash of the image file. The hash is akin to a digital fingerprint. It can be used to prove a match between a tokenized claim and a

file stored anywhere off-chain. If the buyer of a tokenized claim wants to ensure that they can access the off-chain image file in the future, they could locally store a copy of the image file—perhaps even in the same wallet that stores the private key required to claim ownership of the token. In this case, the digital artwork would not require a custodian.

The same cannot be said for tokenized claims that pertain to custodied physical assets, since DLT cannot enforce a link between a tokenized ownership claim (on-chain) and the pertinent physical asset (off-chain). A trusted caretaker, curator, or other conventional intermediary is required to uphold the tokenized ownership claims that are stored on the distributed ledger and registered to an investor's digital wallet address. Examples of custodied physical assets with tokenized ownership claims include Pablo Picasso's "Fillette au beret" as well as the aforementioned works by Wladimir Baranoff-Rossiné and Damien Hirst (Sygnum Bank & Artemundi, 2021). Figure 8.1 provides an illustration of tokenized claims for custodied assets and tokenized claims for assets without a custodian.

It remains to be determined how various jurisdictions will treat tokenized ownership claims for physical assets. Tokenized ownership claims are not necessarily binding, and custodians of physical assets are not liable by default. For art investors, regulatory developments are thus of equal importance to the ongoing technological developments.

Most distributed ledgers are understood as *isolated networks*. Isolated networks are sometimes advantageous, and other times, they are not. For

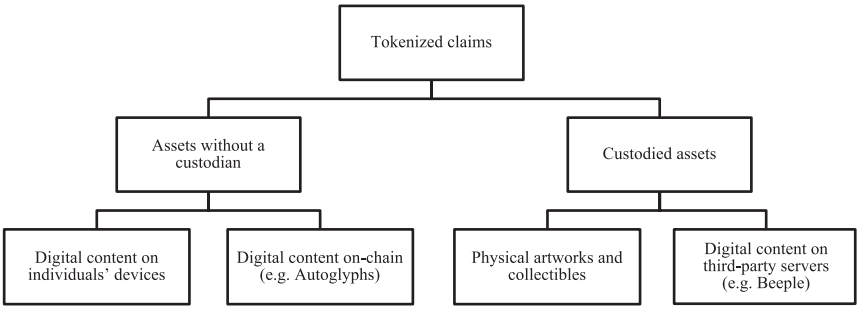

Fig. 8.1 Tokens for custodied assets and tokens for assets without a custodian

holders of fungible cryptocurrencies, to determine how many units of a cryptocurrency one owns, it is sufficient to read from the public ledger. Isolation, in this case, is not a problem, just as isolation is not a problem for owners of Autoglyph NFTs that are fully on-chain. If, however, one deals with tokenized claims for custodied physical assets, there must be a bridge between the DLT realm and the physical realm. If there is no bridge between these two realms, then investors risk buying a token that represents the ownership of nothing but the token itself.

For tokenized physical artworks, there is a need for evidence that attests to the asset's authenticity and condition as well as evidence that attests to the custodian's reputation. Without evidence of reputation, unethical owners of artworks can sell an 'exclusive ownership' token registered on Ethereum plus an 'exclusive ownership' token registered on a different ledger like Polkadot, with no intention to honor the promise. Investors face additional risks due to the fact that physical art is a *movable asset* that can be stolen or shipped across jurisdictions (Velthuis & Coslor, 2012; Meistere & di Torcello, 2018). For tokenized claims that pertain to physical assets, certifications issued by trusted third parties are irreplaceable, and regulation remains crucial.

Art Markets, AML/KYC Regulation, and Identification

Art appeals to investors for financial reasons as well as aesthetic or non-pecuniary reasons (Campbell, 2008; Velthuis & Coslor, 2012; Korteweg et al., 2016). First, art has less volatility and close to a non-changing rate of return over long holding periods. This is largely due to an artwork's low correlation with abstract financial instruments and the practical impossibility of a panic situation that incurs a double-digit decline. Second, art can generate dividends from efficient active management strategies, such as loaning artworks to museums. Finally, since art is a movable asset, it is not permanently confined to one jurisdiction, and its value is not always denominated in the same currency. A painting, diamond, or watch is easier to buy, sell, and move freely across jurisdictions than real estate. Art

is thus "the ultimate offshore," since a physical artwork can be stored in one country while the buyer's money is stored in another country (Meistere & di Torcello, 2018).

Until very recently, art markets allowed participants to conduct high-value transactions with cash, a low level of regulatory oversight, and sometimes no identification checks. One case from the famous Panama Papers, leaked in 2016, illustrated how the art trade's anonymity allowed the Nahmad family to disguise their identity as the owner of an artwork involved in a legal restitution claim (Reyburn, 2016). In 2020, two Russian billionaires used a shell company to effectively obscure their identities as art investors, bypass United States' sanctions, and purchase over USD $18 million of artworks (Portman & Carper, 2020).

In response to identification problems such as these, regulators placed stricter demands on art markets. On 10 January 2020, Member States of the European Union enforced the Fifth Anti-Money Laundering Directive (5AMLD). The 5AMLD subjects intermediaries in the art market to the same requirements as banks, real estate agents, and notaries. For transactions (or a series of transactions) valued at €10,000 or more, art dealers must now register with a national government agency, and art investors must verify their identities and undergo customer due diligence (CDD) checks (Directive (EU) 2018/843, 2018). Similarly, on 1 January 2021, the United States extended the 1970 Bank Secrecy Act, so that the Act affects antiques and art dealers (National Defense Authorization Act for Fiscal Year 2021, 2020). Following these regulatory developments, KYC processes are more important for financial institutions that interact with art dealers, art galleries, art-secured loans, freeports, and auction houses' clients. The source-of-wealth (SOW) and source-of-funds (SOF) are also of increased importance and must now be identified.

If a financial institution advises a client who has an artwork as a SOF, the institution needs records, such as receipts, the auction catalogue's listed sale price of the artwork, sale prices of other works by the same artist (to check for major discrepancies), expert evaluations, and a confirmation that the work is not listed in databases such as Interpol's Stolen Works of Art Database or the FBI's National Stolen Art File (NSAF). Information about the permanent attributes of assets can be embedded in

tokens. If this information is digitized, this will improve the efficiency of the database checks.

It is likewise possible, from a technical perspective, to store identity information about art market participants on a public ledger: one could use, for example, Ethereum's ERC-725 identity claims. Identity information stored on a publicly viewable ledger would, however, conflict with the art market's norms of discretion as well as laws like Europe's GDPR. A method that stores natural persons' identity information off-chain is thus required. Common options include paper-based documents or PDF files, but these options are not machine-readable and are therefore not the most efficient. For the off-chain storage of machine-readable identity information, common X.509 certificates can be used. So, too, can an emerging standard for digital identities named *verifiable credentials* (VCs) (Chadwick et al., 2019; Sporny et al., 2019). VCs can potentially be used in combination with a crypto-asset wallet, so that investors can control the exchange of both tokenized claims and off-chain identity information.

Digital Wallets for Tokenized Claims and Off-Chain Identity Information

Digital wallets are a promising area of research and development, following the European Commission's recent announcement of a Digital Identity Wallet (European Commission, 2021a). Today, it is already possible to use various Ethereum wallet applications to exchange both identity information (stored on-chain in machine-readable ERC-725 format) and crypto-assets (such as fungible tokens, NFTs, and Ethereum's native currency), but this option is not GDPR-compliant. It is also possible to use a *custodial* wallet offered by companies like Binance or Coinbase to exchange both machine-readable identity information (stored off-chain on company-managed servers) and crypto-assets. This option incurs *vendor lock-in*, which means that market participants cannot export their digital identity information or AML/KYC credentials in a standardized form that can be used with other intermediaries.

There is a third option, which is a work-in-progress: a *non-custodial* wallet that allows investors to control the exchange of standardized, machine-readable identity information (off-chain) as well as tokenized claims (on-chain) (Ramsey, 2020). The identity information, for this third option, can be stored in VC format on a device that is managed by the individual investor. The identity information does not have to be stored on a company-managed server. Developers refer to this non-custodial method of digital identity management as *decentralized* or *self-sovereign* (Preukschat & Reed, 2021).

VCs are a more flexible option for machine-readable identity information than X.509 certificates. The World Wide Web Consortium recommended VCs as a standard in 2019, whereas X.509 certificates were initially introduced in 1988 (Sporny et al., 2019). X.509 certificates are commonly used to identify servers, hence they are the backbone of today's World Wide Web. VCs extend the capabilities of X.509 certificates to identify natural persons and *smart devices*. VCs allow subjects to hold and present multiple certificates from different issuers; they can help ensure that semantic attributes are machine-readable across domain barriers; and they can be used in combination with ZKPs to satisfy natural persons' privacy requirements. The public keys of VCs' issuers can be registered on a DLT-based *public key infrastructure* (PKI) or else on a PKI managed by a certificate authority (Preukschat & Reed, 2021; Tobin, 2018).

Companies like Evernym and Trinsic as well as Linux's Trust over IP Foundation are notable developers of decentralized identity solutions. At present, these organizations do not offer a wallet app that allows investors to control the exchange of both off-chain VCs and on-chain tokens. This complex type of exchange would constitute a major advance for art investors that wish to comply with regulators' identification demands without significant privacy compromises. This type of exchange could also benefit members of the general population, who will perhaps in future hold *central bank digital currencies* (CBDCs) and exchange off-chain VCs in accordance with nascent digital identity policy frameworks from Europe and the Anglosphere (Gross et al., 2021; Neuerer, 2021).

The storage of VCs off-chain avoids the most egregious privacy problems, but this is not sufficient for art investors that want to selectively

disclose just some information that is contained within VCs (to comply with regulators' transparency requirements). For these investors, ZKPs are required in combination with VCs stored off-chain.

Zero-Knowledge Proofs for Selective Disclosure

In the art market, there is a high demand for discretion, and consequently, there are informal requirements for the preservation of participants' anonymity (Day, 2014). On the other hand, regulators demand transparency and auditability of transactions. For a tokenization platform to achieve sustainable success, it must strike a balance between participants' demands and regulatory compliance. ZKPs can assist here.

Without ZKPs, DLT is not acceptable to privacy advocates. It does not make sense, simply put, to store private information on a public ledger. Likewise, it does not make sense to share a comprehensive list of private transactions with a global audience. It is not difficult to compile an individual wallet's transaction details, to link the on-chain transaction data with off-chain identity information (like KYC data from exchanges), and to thereby construct a comprehensive buyer/seller profile (Biryukov & Tikhomirov, 2019; Meiklejohn et al., 2013). Consequently, information stored on a distributed ledger should be considered personally identifiable. This is obviously not desirable for art and collectibles investors. Any decision to store information on a distributed ledger should thus be made with care.

A simplistic DLT-based tokenization platform will inevitably confront the so-called *verifier's dilemma.* If an entity wants to be sure that a statement about data is correct (e.g., a transaction is legitimate because the amount that the receiver gets is equal to the amount that the sender spent), one would intuitively expect that the entity needs to see the data and to independently compute the result of the algorithm (Luu et al., 2015). For complex statements, this can have negative consequences on performance, especially for public ledgers that have a high number of verifiers. Even more problematic is the amount of information exposed to

the verifier. In most cases, the verifier is granted access to more information than is strictly required—often more than the entity that wants to prove the statement would like to reveal.

ZKPs can potentially solve the verifier's dilemma. With a ZKP, the prover can convince the verifier of a statement about the integrity of a computation without revealing the computation's result or any other information in excess of what they intended to prove (Goldwasser et al., 1989). Instead of receiving the data and recomputing the algorithm, the verifier will solely check an often-succinct proof that attests to the correctness of the prover's statement. Hence, ZKPs can strictly separate the visibility of data or a computation from the verification of its authenticity or correctness (Platt et al., 2021). Instead of revealing no information (and not being transparent) or revealing excessive information (i.e., sharing all data needed to replicate a computation), ZKPs allow a party to selectively disclose the information required and nothing in excess of this.

More specifically, ZKPs can allow investors to disclose basic things like proof of legal age or proof of a KYC check's completion. ZKPs can thus satisfy generic AML, CFT, and KYC requirements without forcing art market participants to disclose comprehensive identity information (Morais et al., 2019). This makes ZKPs attractive for art and collectibles investors, since they help balance discretionary demands and compliance requirements.

Proposed Technology Stack

We propose a technology stack that facilitates the exchange of tokens and identity information across various platforms and domains in a privacy-preserving manner (Fig. 8.2). It aims to avoid the problem of vendor lock-in (i.e., the provision of digital identity information and due diligence by a trusted third party that is platform-specific or application-specific). This, however, does not imply that market participants can remain isolated within the DLT realm and entirely avoid trusted third parties, regulators from various jurisdictions, or the physical realm. Trusted third parties act as custodians of the physical artworks and collectibles (or any other object that is tokenized), certify the authenticity of

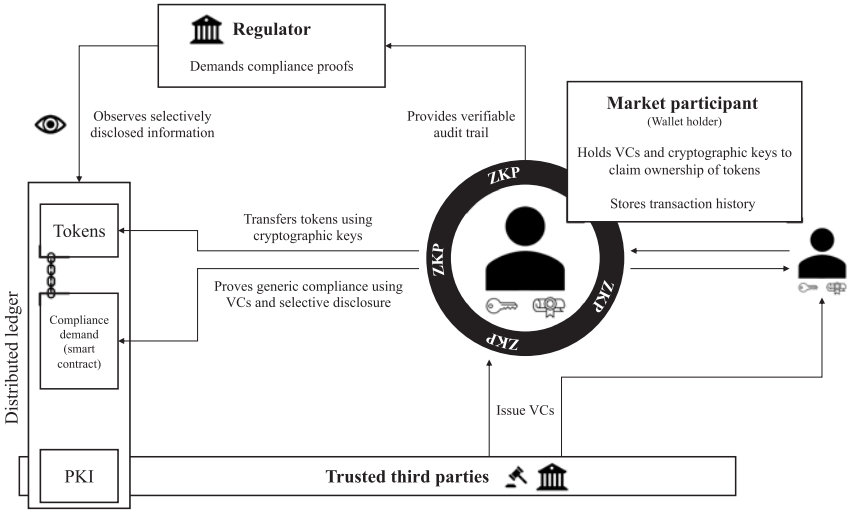

Fig. 8.2 Our proposed technology stack: DLT, VCs, and ZKPs

assets, and issue documents that are required by regulators. If a company-managed exchange acts as a trusted third party and assumes responsibility for the transaction of both ownership claims and compliance information, then vendor lock-in is the result. Investors would need to return to the same exchange in order for their claims to be recognized as valid and tradable, which undermines DLT's general ethos of interoperability (Sunyaev et al., 2021).

Our proposed DLT-based exchange involves a seller that holds tokens and identity-related VCs, as well as prospective buyers that also hold identity-related VCs. A trade between a buyer and a seller can occur under the following conditions:

1. The seller can use VCs (stored off-chain) to disclose to the prospective buyer important information about the physical asset (if this information is not already embedded within the token's smart contract, stored on-chain).
2. A smart contract can automatically demand generic compliance information (that is not specific to any jurisdiction). Both parties can then prove to the smart contract that they have satisfied this generic

compliance demand and thereby fulfilled the pre-requisites for the token transfer.

Generic compliance information may include the following: proof that one possesses a valid ID, proof that one is above a certain age limit, or proof of permission to engage in a particular transaction (issued by a trusted third party such as an accountant or a tax authority). Unique handling codes could also be registered as part of the transaction, which would enable various tax authorities to automatically recognize and categorize the transaction. If generic compliance information is not sufficient, sellers could hypothetically issue smart contracts that demand compliance information that is jurisdiction-specific. A smart contract such as this would only accept a transaction if a specific regulation's requirements were satisfied. This approach to software engineering is sometimes referred to as *compliance by design* (Kokash, 2014).

Selective disclosure (via ZKPs) can hide from a public ledger the identity of the tax authority's employee who signed the compliance-related VC demanded by the smart contract. For more specific privacy benefits, ZKPs can also be used to hide the addresses of the wallets involved in a token transfer, so that the only visible record consists of proof that the tokens spent coincide with the tokens received (Ben-Sasson et al., 2014). The transaction would thus consist of: (1) a ZKP for the transfer of the token (value), and (2) a ZKP that satisfies the automated request for generic compliance information, without revealing any identity information that is not required by various regulators. The supply of generic compliance information can potentially reduce a tokenization platform's risk of prohibition. This risk is serious, given the European Commission's recent position on "anonymous crypto-asset" transactions (European Commission, 2021b).

Outlook

In this chapter, we endorsed the prospective use of DLT for tokenized claims that pertain to custodied physical assets, digital certificates for off-chain identity management, and ZKPs for selective disclosure. We

acknowledged the art market's recent regulatory challenges, specific to the identification of market participants and the off-chain storage of identity information. More broadly, we discussed a digitized paper trail as a viable alternative to the art market's inefficient and sometimes incomplete paperwork that is difficult to audit (Campbell, 2008).

Tokenized claims for physical artworks and collectibles are evidence of the increasing interest in tokenization, outside the limited domain of cryptocurrencies (O'Dair, 2019). Tokenization is becoming a powerful force for innovation, investment, and new or revised business models (Sunyaev et al., 2021; Treiblmaier, 2021). This is partly due to the reputation of distributed ledgers as "neutral" platforms that are beyond the control of any particular company or government (Fridgen et al., 2019). DLT offers investors and creators of artworks and collectibles the unique opportunity to exit single-provider, proprietary systems, and to interact with global stakeholders from previously disparate, closed systems. DLT potentially entails the creation of a global market wherein investors are not required to register with company-managed, custodial exchanges. The realization of this technological potential is, however, contingent upon regulatory developments in various jurisdictions.

The European Commission's recent policy package consists of four legislative proposals that greatly enhance the European Union's existing AML/CFT framework. Specifically, the policy package aims to "improve the detection of suspicious transactions and activities," which includes "transfers of crypto-assets." The policy package also strengthens due diligence checks and prohibits the use of "anonymous crypto-asset" transactions (European Commission, 2021b).

Tokenization thus entails new opportunities for art and collectibles markets as well as new regulatory challenges and unresolved conflicts. The most notable is the tension between investors' demands for privacy and regulators' requirements for transparency and auditability. In response to this tension, we suggested the use of digital certificates (stored off-chain for GDPR compliance) and ZKPs, so that transaction details and identity information can be selectively disclosed to regulators and financial institutions (for 5AMLD compliance). Although it is difficult to strike a balance between investors' and regulators' respective interests, we

believe that this is possible with a technology stack that combines DLT-based tokenization, off-chain identity information, and ZKPs.

Although the proposed technology stack is a work-in-progress that is specific to art and collectibles markets, it could also be treated as a general prototype for the privacy-preserving exchange of NFTs, fungible tokens, digital currencies, and off-chain identity information. A successful technology stack for the art market could provide valuable insights about the design of a central bank digital currency (CBDC), since a CBDC system must also balance the requirements of privacy and auditability. The European Central Bank (ECB) recently proposed four work streams for their digital euro experiments. One stream investigated how AML/KYC procedures can be addressed in a setup that combines DLT, tokenization, and digital identity management (Gross et al., 2021).

We limited this chapter's scope to tokenization for art and collectibles markets, since this area of research and experimentation is not beholden to a central bank's vast array of stakeholders, nor is it subjected to the massive scalability requirements of a sovereign currency. We believe that the privacy-preserving exchange of tokenized art investments constitutes an opportunity for research that is both ambitious and appropriately limited.

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