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Ledger to ledger: off- and on-chain auditing of stablecoin

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Abstract. To assess the financial statements of companies that invest in stablecoin, a digital representation of a fiat currency managed and backed by a blockchain, the auditor must collect evidence of transactions from the blockchain (on-chain) or from an off-chain ledger managed by an intermediary. This study aims to expand the understanding of such transactions, outline possible configurations for the recognition of stablecoin balances and transactions in financial statements, and audit procedures for collecting evidence of these transactions. Based on actual transactions of stablecoin registered on the Ethereum blockchain, we present a hypothetical case of the accounting history of an audited company to demonstrate the challenges in establishing accounting and audit procedures for these novel transactions. We observe an abundance, diversity, and unprecedentedness in the stablecoin transactions studied. We further identify the need to adapt current audit procedures and create new ones, and rethink the very process of doing so. The findings could help auditors obtain more significant knowledge of the information required to assess a company's financial statements when such statements include stablecoin transactions. In addition, the study addresses the evolving relationship between auditing, accounting, and information technology, and the problems in integrating accounting and information technology.

Keywords: Auditing; blockchain; off-chain; on-chain; stablecoin.

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1. INTRODUCTION

In traditional off-chain ledgers (recorded outside the public blockchain), established payment and asset control systems typically use a trusted, centralised entity to validate and store transfer records (Drescher, 2017; OCC, 2021). Transactions in these off-chain ledgers are limited by the functionalities of the information systems that manage these ledgers and by the legal regulations established in the host jurisdictions of the entities authorised to maintain records of these transactions. Reconciling the balances and transactions in the accounts of an audited company with those recorded in these off-chain ledgers through external confirmation is one of the main duties performed by an auditor when assessing financial statements. A land acquisition, for instance, may affect five off-chain ledgers: the registry office ledger that records the transfer of the asset; the intervening bank's (assuming the buyer and seller use different banks) ledgers that record the money transfer; the accounting ledgers of the acquiring and selling companies recording the accounting transaction; and the bank accounts representing the assets exchanged in the transaction. The security conferred by the bank and property records allows the auditor to collect information only from the financial institution to form an opinion on the existence, occurrence, and fullness of the balances and transactions related to monetary availability and from the land registry to prove the transfer of land ownership.

With the technological advent of blockchain and smart contracts, a buyer of land can use a virtual asset, specifically stablecoin, in addition to bank intervention or cash, as a means of payment. Stablecoin is a digital representation of a fiat currency managed and supported on a public blockchain network (ledger on-chain), and tied to and secured primarily either by fiat currencies deposited with a financial institution (fiat-backed) or by crypto assets (crypto-backed) (G7 Working Group on Stablecoins, 2019; OCC, 2021). The buyer (company) can transfer stablecoins from their wallet or a third-party wallet to the seller (counterpart). The company can, through a wallet, directly control their stablecoin balances and transactions registered in the blockchain. In this paper, we refer to this type of control of balances and transaction as self-custody (Self). In third-custody, the company chooses to entrust an intermediary with the control of its virtual asset [stablecoins] (Dixon, 2021). This middleman, called the virtual asset service provider (Vasp) by the Financial Action Task Force (FATF, 2019), controls stablecoin balances and

transactions internally through an off-chain ledger. The company making or receiving a payment uses the wallet of the Vasp. We refer to this type of control of balances and transactions as Vasp. In addition to these transactions, the company can also conduct transactions in the internal platform environment of the Vasp, or effect financial transactions involving decentralised finance (DeFi), which is an application constructed in blockchain and controlled by a set of smart contracts.

The disclosure of stablecoin transactions from the off and on-chain ledgers in the company´s accounting statement will allow the auditor to direct those seeking information regarding balances and transactions of the stablecoin under analysis. The dissection of off- and on-chain transactions is necessary because, as Coppola (2020) finds, what exists in the blockchain can be very different from what exists in reality. The blockchain provides information on the owner of the real asset, but not on its location and the condition in which the real asset exists. The accountant and the auditor who certify this information are jointly responsible for directly or indirectly reporting the location and nature of use of the asset, and the condition in which the asset is represented on the blockchain. The auditor must establish specific procedures to collect sufficient and appropriate evidence of the stablecoin transactions in this tangle of transfers, to determine compliance with accounting standards in the financial statements of companies with transaction balances in stablecoin.

This topic is relevant for accountants, and more so for auditors. First, the latter may have little or no experience with crypto assets/stablecoin and therefore, may not fully grasp the challenges and opportunities that an audit of these assets may present (Association of International Certified Professional Accountants [AICPA], 2020). Second, the study addresses the evolving relationship between auditing, accounting, and information technology and the problems faced in integrating accounting and information technology. Third, several studies in the existing literature demonstrate only conceptual information of how blockchain and smart contract technologies can be applied to accounting or auditing. Exceptions to these articles are the works of Dai and Vasarhelyi (2017), Rozario and Vasarhelyi (2018), Simoyama et al. (2017), and Weigand et al. (2020) that illustrate the possible use of blockchain to conceptualise accounting, continuous auditing, and public accounting systems. In relation to the practice of auditing, Vincent and Wilkins (2020) also developed a model to assist auditors with customer acceptance and continuity decisions and

identify the cryptocurrency risks that should be considered during audit planning and the collection of audit evidence. The AICPA (2020) developed nonauthoritative guidance about digital assets accounting and auditing under U.S. Generally Accepted Accounting Principles (GAAP), and advanced some key questions about accounting for stablecoin holdings.

The scarcity of scientific articles reviewing stablecoin transactions and norms given this emerging and complex theme is an obstacle to the development of new procedures. This study aims to explore stablecoin transactions performed on off- and on-chain ledgers or between these ledgers, and to present possible accounting narratives for the recognition of stablecoin transactions and audit trails for collecting the transactions recorded in these ledgers. To achieve the objectives of the study, we present hypothetical examples of transactions with stablecoins in the accounting history of an audited company, based on actual transfers of stablecoin registered on the Ethereum blockchain. These examples can help auditors obtain more significant knowledge of the information required to assess a company's financial statements when the latter includes stablecoin transactions.

The paper presents a literature review of studies related to the technical and business aspects of blockchain, smart contract, stablecoin, decentralised finance, and Vasp in Section 2. It then presents an accounting overview of stablecoin in Section 3, followed by examples of transactions with stablecoin and discussions regarding the audit of these transactions in Section 4. Finally, Section 5 includes a discussion of the associated operational difficulties and the role of accounting in recording operations with stablecoin, in addition to proposals for future scientific studies on the theme.

2. THEORETICAL FRAMEWORK

2.1. Blockchain transactions and accounting

Blockchain technology, a subset of distributed ledger technology (DLT), functions as a ledger that enables the transfer of value or its representation from one person to another without the need for an intermediary to sanction or guarantee the exchange; it also facilitates complete tracking of the transaction from its origin, in contrast to what occurs in a simple transfer of information (De Filippi & Wright, 2018; Drescher, 2017; Government of Liechtenstein, 2019; Nakamoto, 2008; Wieninger et al., 2019; Zheng et al., 2020). Bonsón and Bednárová (2019) and Drescher (2017) summarised the types of blockchain according to their

authorisation to participate in the network and limitations on reading, creating, or writing transactions. Drescher (2017) presents versions of the blockchain ranging from the most open to the most closed. The public permissionless blockchain allows everyone to read, create, and write new transactions, while the private permissioned blockchain restricts the ability to read, create, and write new transactions to a preselected group of users. In this study, the term 'on-chain ledger' strictly signifies stablecoin transactions managed on a public permissionless blockchain. By contrast, the 'off-chain ledger' is not managed on a public blockchain, making it a traditional ledger for the purposes of this study.

Every transaction in the permissionless public blockchain is transparent, and anyone can access data regarding transfers using a public key. A transfer or a set of transfers forming a transaction on the blockchain is like a transfer of payment between bank accounts. However, a bank transfer alone does not reveal the underlying business transaction because 'payment systems today operate independently from the business agreements that drive those payments' (Brody, 2021). Similarly, a transfer on the blockchain does not provide business information regarding the underlying transaction and, consequently, cannot inform the accounting entry that this transaction represents. For example, the bitcoin transaction for over $1.16 billion, illustrated in Figure 1, reveals that the public key owner 3G9Za8PmJCXi4p transferred USD 0.56 billion and USD 0.60 billion to the owners of public keys 3Ee3Cft7X4D and 3PKgBYdKoX, respectively. However, this transparent information does not confirm the transaction between the owners of the public keys involved in the transfers, nor does it constitute accounting recognition by the holders of those keys. Which accounting narrative corresponds to these transfers? Is this an intra-company transaction or the sale of an asset? What type of business transaction does this transfer of bitcoin refer to: (1) the acquisition of real estate and crypto assets, (2) the acquisition of stablecoin and equity interests, (3) dividend payments and stablecoin acquisition, or (4) pension plan contributions and tax payments? Figure 1 highlights these possible journal entries.

Tx Hash d486aeb0e59181fd1addb4aa69ce04d638188fc1125c424899267e8ed6a8af24

From	3G9Za8PmJCXi4pnqN82Jt5dSeN262Ftefj	88,857.24519026 BTC
To	3Ee3Cft7X4DbRzMoBdaKWrCZ4AqriA5sbF	43,185.96060000 BTC
To	3PKgBYdKoXABCa8ec5Ypm73nKeAvJxtnSb	45,671.28431179 BTC

Accounting Company

(1) Acquisition of Real Estate and Crypto Assets

D	*Lands*	$0,56 Bi
D	*Intangible Cardano*	$0,60 Bi
C	*Intangible BTC*	$1,16 Bi

(2) Acquisition of Stablecoin and Equity

D	*Indian Rupee Token Stablecoin Rupiah*	$0,56 Bi
D	*Shareholdings 'Cia Aracaju'*	$0,60 Bi
C	*Intangible BTC*	$1,16 Bi

(3) Dividend Payment and Acquisition of Stablecoin

D	*Dividends payable*	$0,56 Bi
D	*Swiss Franc Stablecoin Crypto Franc*	$0,60 Bi
C	*Intangible BTC*	$1,16 Bi

(4) Contributions to Pension Plan and Tax Payments

D	*Contributions to Pension Plan*	$0,56 Bi
D	*Tax Payments*	$0,60 Bi
C	*Intangible BTC*	$1,16 Bi

Figure 1. Examples of hypothetical accounting entries for a bitcoin transaction
Source: Authors' elaboration based on www.blockchain.com/btc/tx/d486aeb0e59181fd1addb4aa69ce04d638188fc1125c424899267e8ed6a8af24

Doubts also arise about the recognition of revenue and expense. Were the gains or losses arising from this financial transaction, measured at fair value and recorded in the blockchain account 3G9Za8PmJCXi4p, recognised in the income statement before or at the time of transfer? Is the fair value of functional currency transactions correctly translated? Answers to questions regarding these transfers recorded on the blockchain lie in the accounting policy choices behind the accounting benchmarks set by the company's accountants and directors and where necessary, certified by the auditor.

2.2. Wallet control

To interact with a permissionless public blockchain, the company needs a wallet. A wallet consists ‘of a public address or key that appears on a distributed ledger and a private key, which is closely held by the individual or entity with control over the assets attributed to that public address’ (Dixon, 2021, p. 3). The public key resembles a bank account, and a private key is a ‘user code that serves as a digital signature in the distributed ledger in the form of a unique string of numbers and letters’ (FATF, 2019, p. 27). The company can carry out transactions with the crypto asset assigned to the public key directly in the blockchain if it possesses a private key as well. The company can also interact indirectly with the blockchain through the wallet of a Vasp, the procedure of which is described later in the text. Outsourcing control of the public keys to an intermediary can create new risks, such as storage costs, intermediary bankruptcy, and fees charged by the Vasp.

In contrast to outsourced control, direct control of the public keys for stablecoins allows their owner access to new types of transactions as well as to new assets owing to the programmability of the blockchain network and the creativity of smart contract encoders. In this article, the determination of wallet ownership is the mainstay for mapping stablecoin transactions, as it is based on the interactions between own and third-party wallets. We use the terms 'Self' and 'Vasp' for own and third-party wallets, respectively.

2.3. Smart contract

According to Szabo (1994), a smart contract is a computerised protocol that executes a contract’s terms. The concept emerged with the development of blockchain (Bonsón & Bednárová, 2019). The smart contract is a programme code executed in a distributed manner by all nodes supporting the underlying blockchain-based network (De Filippi & Wright, 2018; Zheng et al., 2020). The conditions encoded in the smart contract—especially the one built on Ethereum’s blockchain (Buterin, 2013)—enable the control of value transfers between the parties of a transaction and the automatic execution of the contractual terms without the intervention of a trusted third party (De Filippi & Wright, 2018; Zheng et al., 2020). The smart contract, among other uses, usually acts as a ledger controller in the account balance's public key.

Execution of contractual functions, in the form of the issuance ('Emit', from the public key 0x00000000, null address), transfer, or termination ('Burn', to the public key 0x00000000, null address)—for example, of stablecoin—changes the status of that ledger's account balances, as shown in Figure 2.

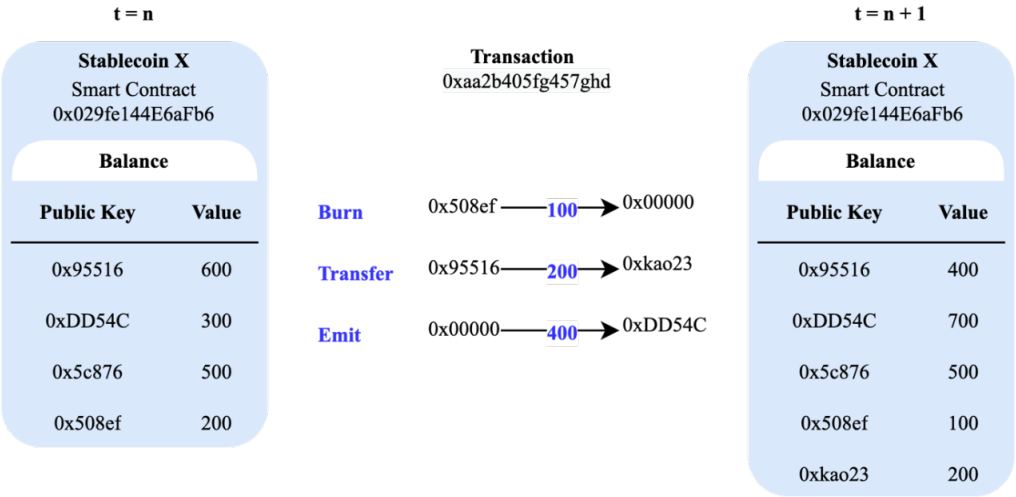

Figure 2. Examples of smart contract transactions
Source: Authors' elaboration

The asset position of all public keys is updated from the record of transactions in the blockchain (Zheng et al., 2020). From the smart contract balance shown in Figure 2, we can assert that entity 0x95516 transferred 200 coins to entity 0xkao23, but there are no elements to define the business agreements that generated this transfer.

2.4. Stablecoin

According to Tapscott and Tapscott (2018), stablecoin is a type of cryptocurrency that seeks to maintain a consistent value over time by binding to an underlying asset, such as a fiat currency like gold, or to a set of assets that keep the stablecoin price constant. Most stablecoins are tokens created on one or several public blockchains managed by a set of smart contracts, and they serve to store or transfer the underlying fiat currency's value (HM Treasury, 2021; OCC, 2021). The main types of stablecoin are fiat-collateralised, crypto-collateralised, metal-backed, and algorithmic supply. The fiat-collateralised form is backed by a 1:1 fiat-currency reserve recognised in a financial institution's off-chain ledger. Auditing can ensure

that the company has a reserve balance that aligns with the number of stablecoins in circulation (G7 Working Group on Stablecoins, 2019; OCC, 2021). Figure 3 illustrates an attestation of the existence of collateral assets held by a stablecoin issuer at depository institutions equal to or greater than the total supply of stablecoins registered in the smart contract 0x8e870d67f at the date and time recorded by the report.

INDEPENDENT ACCOUNTANT'S REPORT

Paxos Trust Company, LLC
New York, NY 10017

We have examined Paxos Trust Company, LLC's below assertions. Paxos Trust Company, LLC's management is responsible for its assertions. Our responsibility is to express an opinion on management's assertions based on our examination. Management's assertions, which are summarized in the attached report, (hereafter referred to as the "Reserve Accounts Report"), which we examined are as follows:

- The Reserve Accounts Report refers to the total supply of Paxos Standard tokens ("PAX") as of January 31, 2020, at 5:00 pm Eastern Time ("ET"). Such PAX, (which also represents the total circulating supply) as denoted under contract 0x8e870d67f660d95d5be530380d0ec0bd388289e1 at 18 decimals at 5:00 pm ET on January 31, 2020 (the "Report Date and Time") is 226,307,039.73, as reported by the EtherScan API and an internally maintained and operated node on the Ethereum network.
- The Reserve Accounts Report refers to the accounts held by the Company at U.S. depository institutions, including U.S. depository institutions to which cash is swept pursuant to a certain deposit placement agreement. The USD balance and, when applicable, amounts backed by U.S. treasuries in the Reserve Accounts is at least equal to or greater than $226,307,039.73 at the Report Date and Time. This does not contemplate the impact of outstanding checks/wires, deposits in transit or other reconciling items.
- The total PAX supply, for which each PAX is assigned a redemption value, strictly pegged at 1:1 to the U.S Dollar by the Company, does not exceed the balance of the Reserve Accounts reported below.

Figure 3. Attestation report
Source: Paxos (2020)

Crypto-collateralised stablecoins are not issued by a centralised authority and do not use fiat currencies or physical assets; rather, they are backed by other cryptocurrencies. However, their value is linked to a fiat currency on a 1:1 basis (G7 Working Group on Stablecoins, 2019; OCC, 2021). By contrast, metal-backed stablecoins are backed by commodities and their value is tied to that commodity. For example, each stablecoin is backed by a gold deposit. Finally, algorithmic supply is a stable cryptocurrency that is not associated with or backed by a traditional or crypto asset, and it correlates closely with the U.S. dollar. This parity is achieved by algorithmically adjusting the coin supply based on demand from the ecosystem (G7 Working Group on Stablecoins, 2019).

In this article, we will not delve into the technical, accounting and auditing aspects of metal-backed and algorithmic stablecoins, or of the transactions related to the issuance and burning of any stablecoin.

2.5. Decentralised finance (DeFi)

Many stablecoin transactions are conducted through decentralised finance (DeFi), which consists of a set of interconnected and interoperable smart contracts and blockchains. DeFi offers crypto-based financial services such as interest-bearing deposits (savings), loans, derivatives, crypto asset exchanges, and insurance. We briefly present the functioning of a DeFi for lending and borrowing, as shown in Figure 4 and as described by AAVE (2021a):

> In order to interact with the Aave protocol, you simply deposit your preferred asset and amount. After depositing, you will earn passive income based on the market borrowing demand. Additionally, depositing assets allows you to borrow by using your deposited assets as a collateral. Any interest you earn by depositing funds helps offset the interest rate you accumulate by borrowing.

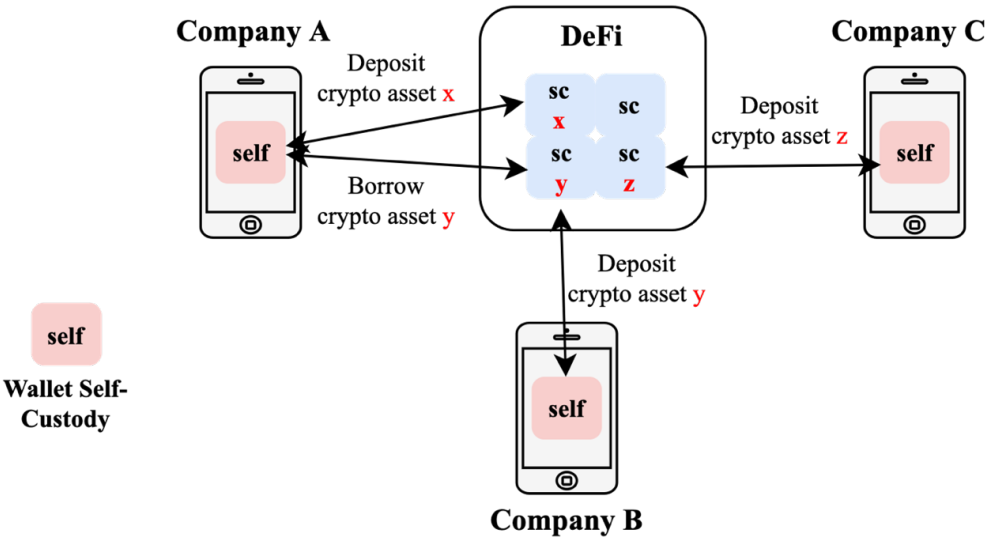

Figure 4. Example of DeFi transactions
Source: Authors' elaboration

In the figure, company A, B and C deposit crypto asset 'x', 'y', and 'z' in the contract 'sc x', 'sc y', and 'sc z' of the DeFi and earn interest in crypto asset 'x', 'y', and 'z', respectively. Company A borrows crypto asset 'y' previously deposited by company B using its deposited crypto asset 'x' as collateral. Company A should repay the amount of crypto asset 'y' plus interest in crypto asset 'y'. The DeFi 'intermediates'

these operations, and there is no interaction between company A (borrower) and company B (provider). These transactions raise some questions: are crypto assets 'x', 'y', and 'z' intangibles or financial instruments? Is there a possibility of intangible 'multiplication'? What will be the model basis for measurement after initial recognition of the intangible 'x', 'y', and 'z'? Are they non-financial transactions? The International Accounting Standard Board (IASB) treats crypto assets as intangible assets; therefore, new methods and premises are necessary for the accountant to judge whether to recognise these new assets and transactions in the company's accounting.

2.6. Virtual asset service provider (Vasp)

According to FATF (2019), usually, a company can exchange crypto assets for fiat currencies or exchange one or more forms of crypto assets on a Vasp platform. Typically, the primary type of Vasp is called an 'Exchange', such as the New York Stock Exchange. Before allowing users to trade on its platform, the Vasp establishes Know Your Customer (KYC) procedures to verify the identity and other information of the company. As briefly shown in Figure 5, the company transfers money (fiat) from its bank account to its Vasp account or transfers crypto assets from its wallet (self) or another Vasp (Vasp) to the wallet of the focal Vasp. Fiat and crypto asset withdrawal transactions take place in reverse in the same way. The company performs transactions with a third party or with the VASP itself internally on the Vasp platform. In this article, Vasp is an intermediary (agent) that facilitates fiat and crypto asset transactions between a company and a counterparty (third party). The Vasp controls all transactions through an off-chain ledger, along with a register in the blockchain for crypto asset deposit and withdrawal transactions.

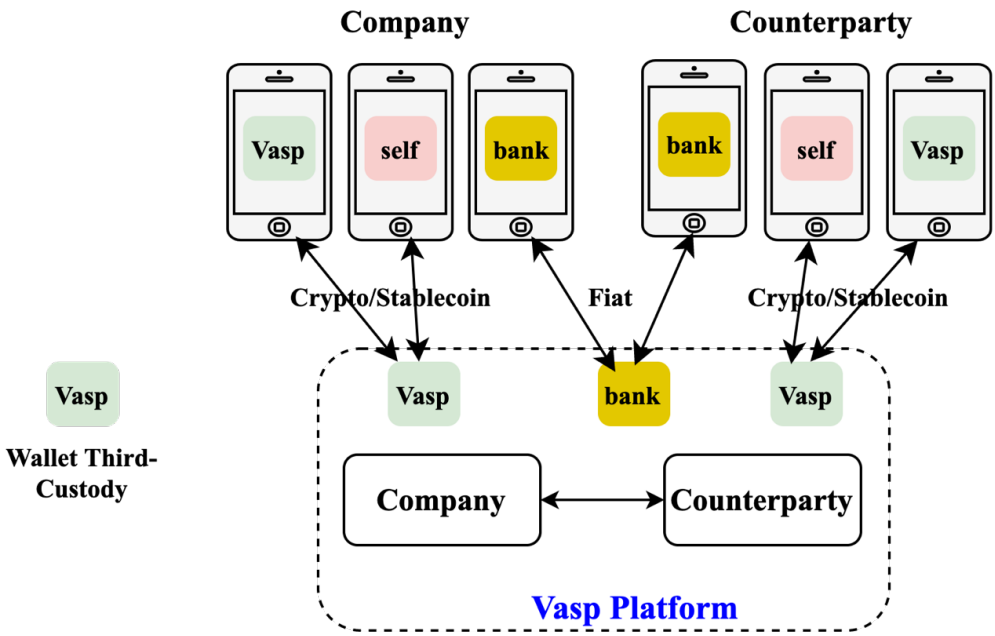

Figure 5. Example of Vasp transactions
Source: Authors' elaboration

3. STABLECOIN ACCOUNTING

Accounting standards for stablecoin do not yet exist. In its document 'Holdings of Cryptocurrencies', IASB (2019) signalled that cryptocurrencies, a subset of crypto assets, are an intangible asset. However, the IASB did not comment on stablecoins. The committee concluded that a cryptocurrency fits the definition of an intangible asset described in IAS 38 because it 'can be separated from the holder and sold or transferred individually', and 'does not give the holder the right to receive a fixed or determinable number of units of currency'. To consolidate this understanding, the IASB (2019) considered the following as elementary characteristics of a cryptocurrency:

I. It is a digital or virtual currency registered on a DLT, and uses cryptography for security.

II. A jurisdictional authority or party does not issue it.

III. Holding it does not give rise to a contract between the holder and another party.

The IASB (2019) also relied on the concept of 'intangible asset' in paragraph 8 of IAS 38. An intangible asset is a non-monetary identifiable asset without physical substance; the essential characteristic of a non-monetary item, as explained in paragraph 16 of IAS 21, is the absence of the right to receive (or the obligation to deliver) a fixed or determinable number of units of currency.

However, the 'right to receive (or the obligation to deliver) a fixed or determinable number of units of currency' is implicit in stablecoin. In effect, the terms of use on the websites of stablecoin issuers state that redemption is on a 1:1 basis, minus the fees incurred on the transaction. For instance, on Circle's website: '...when Circle redeems USDC [stablecoin dollar] for U.S. Dollars, it will always redeem such USDC at a rate of one U.S. Dollar ($1) per one (1) USDC, less fees where applicable' (Circle USDC, 2020).

The acquisition of stablecoin above or below the parity value occurs on exchanges. Such divergences are the consequence of economic factors arising from the circulation of stablecoins outside the platform of the stablecoin issuer (e.g., on an exchange). These factors include supply, demand, the fees charged for transactions executed on an exchange, and the fees commonly required for transfers made on the underlying blockchain network of the stablecoin. These possible differences between quotations for stablecoins and the parity assured at redemption do not impede the classification of stablecoin as a monetary item since the 'right to receive (or the obligation to deliver) a fixed or determinable number of units of currency' is perennial.

According to HM Treasury (2021), based on the legal structure and specific backing arrangement, stablecoins may have characteristics similar to those of e-money. The Office of the Comptroller of the Currency (OCC, 2021), in its interpretation of the possible use of stablecoins and independent node verification networks for payment activities by banks and federal savings associations, states that stablecoins function as a payment mechanism in the same way as systems that carry payment instructions, such as debit cards, checks and electronically stored value (ESV). According to OCC (2021, p. 6), 'in an ESV system, money is exchanged for ESV. This ESV is stored on a computer chip inside a card. The cardholder makes payments by transferring that ESV to another party, who can then redeem the ESV for cash'.

Stablecoins derive from a single source (a smart contract managed by the company issuing the stablecoin); they have the same economic characteristics as cash balances and deposits, and likely 'have similar implications for the prospects of future net cash inflows to the entity or net cash outflows from the entity' (IASB, 2018, p. 35). For illustrative purposes, in this article, we consider fiat-backed stablecoins as a monetary item. In this study, we also consider crypto-backed stablecoins, issued from crypto assets deposited as collateral in smart contract vaults, as monetary items because their functionality in the crypto asset trading universe is equivalent to that of fiat-backed stablecoin.

The control and informational disclosures in relation to stablecoins, which are classified as a monetary item and used as a means of payment, should be similar to that of their underlying assets (i.e., same risks, same rules), according to the technical specifications of blockchains and smart contracts, which control the stablecoin (FINMA, 2019; G7 Working Group on Stablecoins, 2019). To achieve effective control and assist auditors in evidence-gathering, accountants should adopt specific procedures for recognising controlled balances in Self-Custody, Vasp, and deposits in DeFi, in the same way as with physical cash balances and bank deposits, as outlined in Table 1.

Cash, Cash Equivalent, and Stablecoin Balance

Assets	**$**
Cash	444,000
Bank	444,000
Stablecoin (Self)	444,000
Stablecoin deposit (DeFi)	444,000
Stablecoin (Vasp)	444,000

Table 1. Cash, Cash Equivalent and Stablecoin Balance

4. ON- AND OFF-CHAIN AUDITING OF STABLECOIN

An adequate on- and off-chain audit of a company's stablecoin is necessary to identify which ledger has the record on transactions between the company and its trading counterparty. We mapped some types of transactions, as shown in Figure 6. For transactions carried out internally on a Vasp platform (IntraVasp), similar to a stock exchange transaction, it is only necessary to access the information registered in the Vasp's off-chain ledger. For transactions occurring directly between a Vasp

wallet and an own wallet, we look at what happens in the case of physical money transactions and deposits in banks as means of payment. The auditor can mirror the procedures applied to transactions involving physical money and bank deposits. The auditor must initially identify the origin and destination of money transfers. Traditionally, a transaction with money transfers in the 'bank–bank', 'bank–hand', 'hand–bank', or 'hand–hand' forms implies different audit risks. These differences also remain in the transactions involving the use of balances directly controlled by the company or managed by a Vasp: 'Vasp–Vasp', 'Vasp–Self", 'Self–Vasp', and 'Self–Self' forms of transaction. 'Vasp–Vasp' transactions are registered in the Vasp's off-chain ledger and the blockchain. 'Vasp–Self' and 'Self–Vasp' transactions happen between the off- and on-chain ledgers, and these transfers are necessarily registered in the blockchain. The 'Self–Self' transfer occurs exclusively in the blockchain environment. For transactions executed through interaction with DeFi, the auditor must identify the transaction based on their understanding of the operations generated from one DeFi ('Self–DeFi') or the composability and interoperability of the DeFis ('Self–MultiDeFi') triggered in the transaction registered in the blockchain. In 'Self-DeFi', 'Self-MultiDeFi', and 'IntraVasp' transactions, stablecoins exhibit dependence and operate in conjunction with business agreements.

After identifying the ledger in which the transactions are recorded, to demonstrate possible procedures for collecting evidence on the essential aspects of the transactions, we present nine hypothetical accounting entries for a transaction performed by an audited company using stablecoin as the means of payment. The examples are based on real transactions recorded on the Ethereum blockchain and randomly collected on the etherscan.io block explorer, except the transactions related to IntraVasp. Fees paid on recorded transactions were not considered for the purposes of this study. Information regarding the control of the wallet can be collected from websites called block explorers that specialize in presenting transactions with crypto assets, or directly from the other party to the transaction.

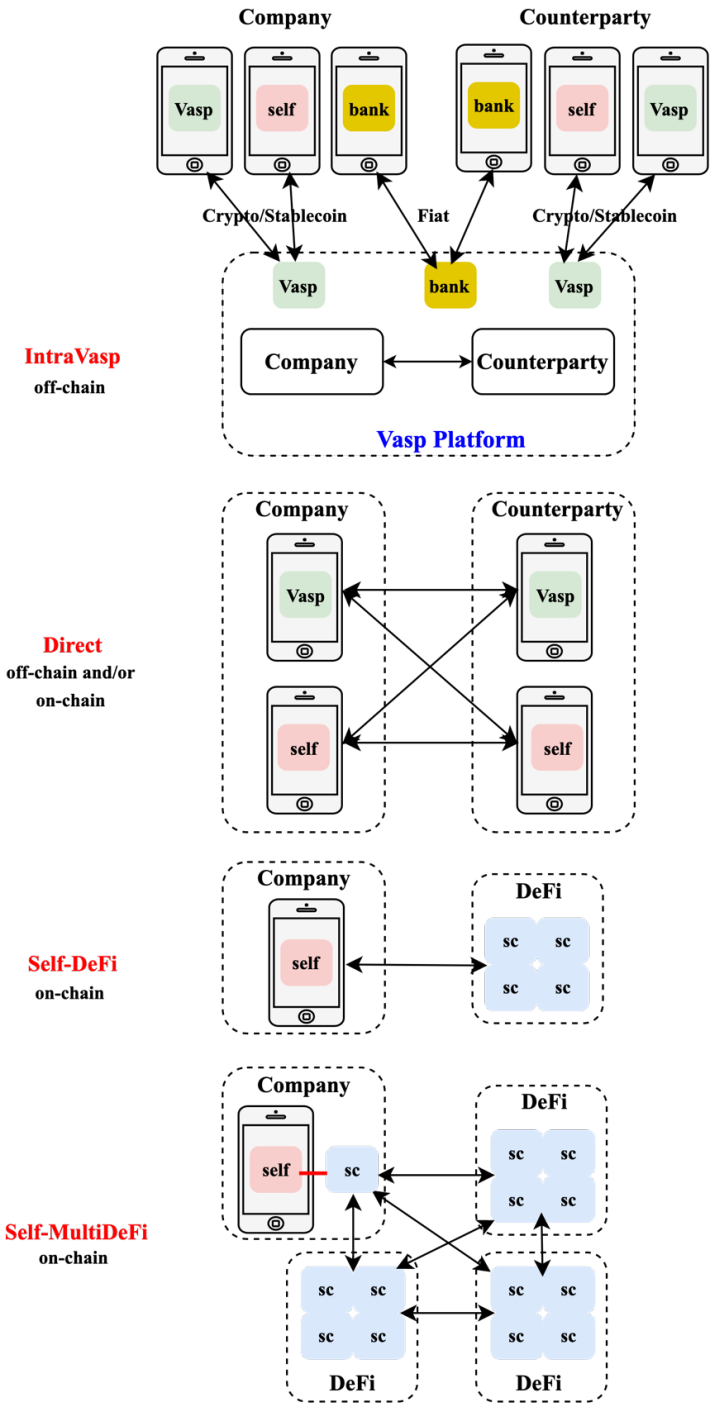

Figure 6. Examples of stablecoin transactions off- and on-chain
Source: Authors' elaboration

4.1. IntraVasp

We classify these transactions as all those that occur internally within a Vasp's operating environment. The accounting entry is conventional, with the inclusion of 'Vasp' to denote the right to the stablecoins that an exchange manages. As shown in Case 1 in Figure 7, the company remits money from its bank account to the platform and acquires stablecoins from a third party. In Case 2, the audited company buys bitcoin with stablecoin. In Case 3, the audited company sells stablecoins for cash and transfers this cash to its bank account.

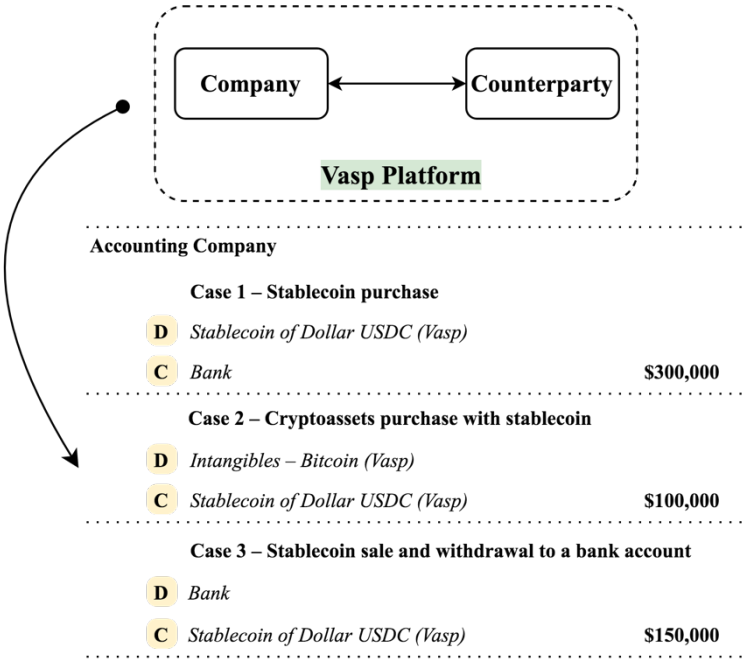

Figura 7. IntraVasp examples
Source: Authors' elaboration

The change in audit procedures for the verification of IntraVasp transactions tends to be insignificant, as the auditor's conclusion will be based simply on cross-checking the audited company's accounts with the off-chain ledgers of the bank and the exchange, for information on the bank transfer and the acquisition of stablecoin dollars, respectively (see Cases 1 and 3 in Figure 7). The compliance procedure for securities acquired on the stock exchange is similar. As described in Case 2, if

stablecoin is used to purchase services, financial instruments, or crypto assets offered on the intermediary's platform, evidence is only gathered by the exchange.

4.2. Vasp-Vasp

As occurs in interbank transactions, in Vasp–Vasp transfers, the audited company uses a Vasp's wallet to send and receive stablecoin to and from third parties who also utilise a Vasp's wallet for transfers. The auditor confirms the transfer's details based on data recorded by the Vasps involved in the transfer. Confirmation of transfer value and date in this audit trail can also be obtained directly from the blockchain registration because the transfer is automatically registered on the blockchain. Figure 8 shows a hypothetical land acquisition case based on stablecoin transfer between Vasps.

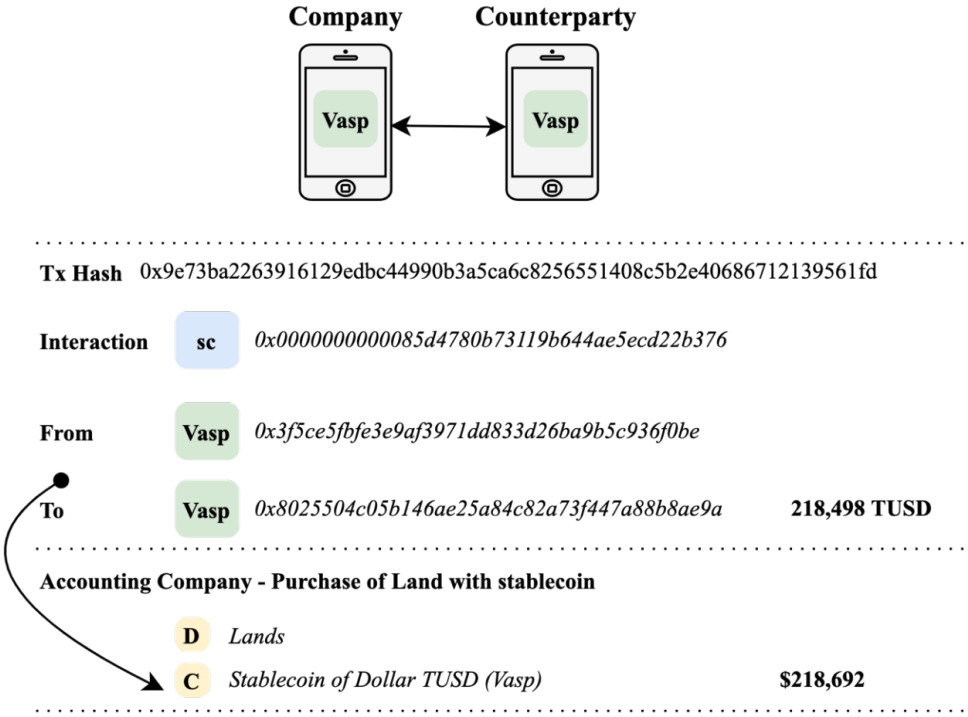

Figure 8. Vasp–Vasp example
Source: Authors' elaboration based on
etherscan.io/tx/0x9e73ba2263916129edbc44990b3a5
ca6c8256551408c5b2e40686712139561fd

The public keys 0x3f5ce5fbf and 0x8025504c0 in which the stablecoins are registered belong to two Vasps. The company by Vasp (0x3f5ce5fbf) send an 'order' for the smart contract (0x0000000000085d) to transfer 218,498 TUSD to the counterparty by Vasp (0x8025504c0), to pay for the purchase of land. The Vasps' off-chain ledgers and the transfer record on the blockchain act as 'witnesses' to the transfers. However, confirmation of all transaction details occurs only after checking the transfer record on the off-chain ledger of the land registry.

4.3. Vasp-Self

Figure 9 demonstrates an example of a Vasp–Self transfer, or a movement of stablecoin between a Vasp account belonging to the audited company and a public key directly controlled by the transaction counterparty. The audited company purchases cars and pays for the cars through stablecoins managed in a Vasp, to a public key controlled by the counterparty. The situation is analogous to the withdrawal of money from a bank and its physical delivery to another part of the business but there will be no information about the destiny of the money. In the case of Vasp–Self, a register of the money transfer (stablecoin) is made on the blockchain. However, the same risk of counterparty identification remains, and the name of the counterparty can be found only in the transfer documents of the product.

When reading transaction 0x524d92755a of the Ethereum blockchain shown in Figure 9, the auditor will find that smart contract 0xa0b86991c6 was triggered to transfer USDC from exchange address 0xd551234ae to the counterparty address 0x4d1f8d195. In Vasp–Self cases, the auditor will confirm the transfer from the exchange and the blockchain registration. However, information about the car seller's identity is only obtainable from the car's purchase invoice or the government car registration body. However, the car seller's identification will not provide complete proof to the auditor that the seller controls the 0x4d1f8d195 key. Conversely, if the audited company had sold the car and received stablecoin from a public key controlled by the buyer, similar uncertainties regarding the identity of the buyer would remain.

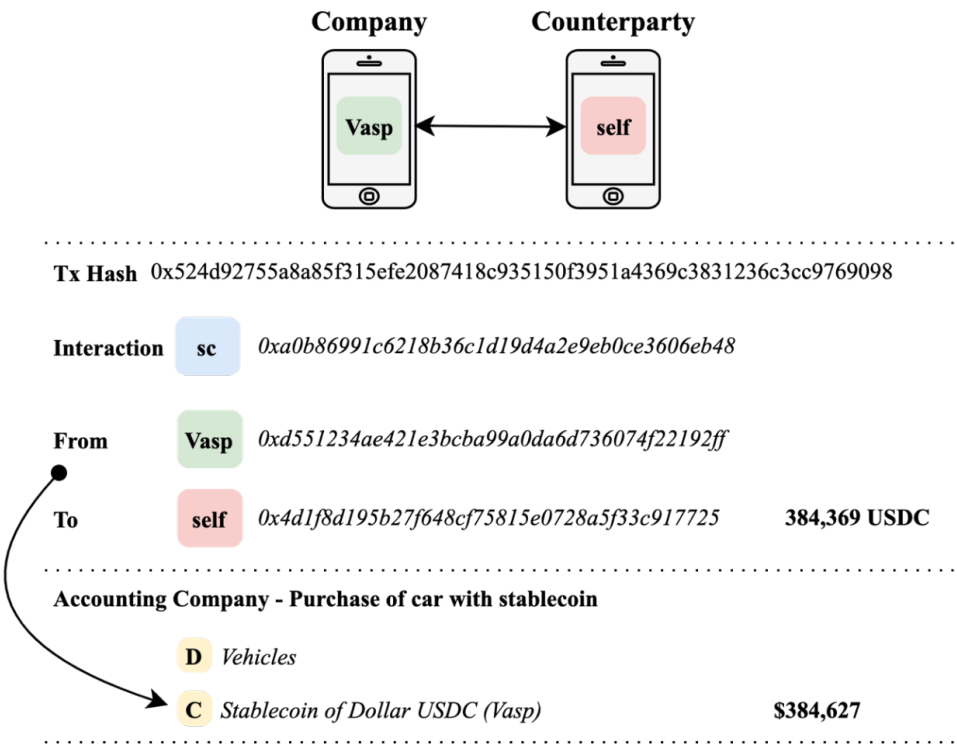

Figure 9. Vasp–Self example
Source: Authors' elaboration based on
etherscan.io/tx/0x524d92755a8a85f315efe2087418c935150f3951a4369c3831236c3cc9769098

4.4. Self-Vasp

Unlike the previous classification, the audited company uses its public keys to send and receive stablecoins to and from third parties using the Vasp's wallet. The company's deposit of money in the counterparty's bank account (hand to bank) represents an approximation of the Self-Vasp transaction. In the hand–bank transaction, the register exists only in the bank's off-chain ledger, but in the Self–Vasp case, in addition to the registration in the Vasp, there is also a registration in the blockchain. In the on-off audit trail, confirmation of the transfer of stablecoins is obtained from the Vasp's off-chain ledger (counterparty) or the blockchain. Unlike the Vasp–Self case, the auditor verifies the counterparty's identity based on information collected by the Vasp or the transfer records of the traded assets.

As shown in Figure 10, for payment of goods, the counterparty transfers by Vasp (0x75d6d5f90) 35.1 million IDRT Indian rupee stablecoins to the company (0x3f5ce5fbf), following the triggering of the contract (0x998ffe1e43f). In this example, if the Indian rupee is not the company's functional currency, the auditor should verify the quotation in that currency to ensure that 35.1 million IDRT are worth U$ 2,392.44 in stablecoin.

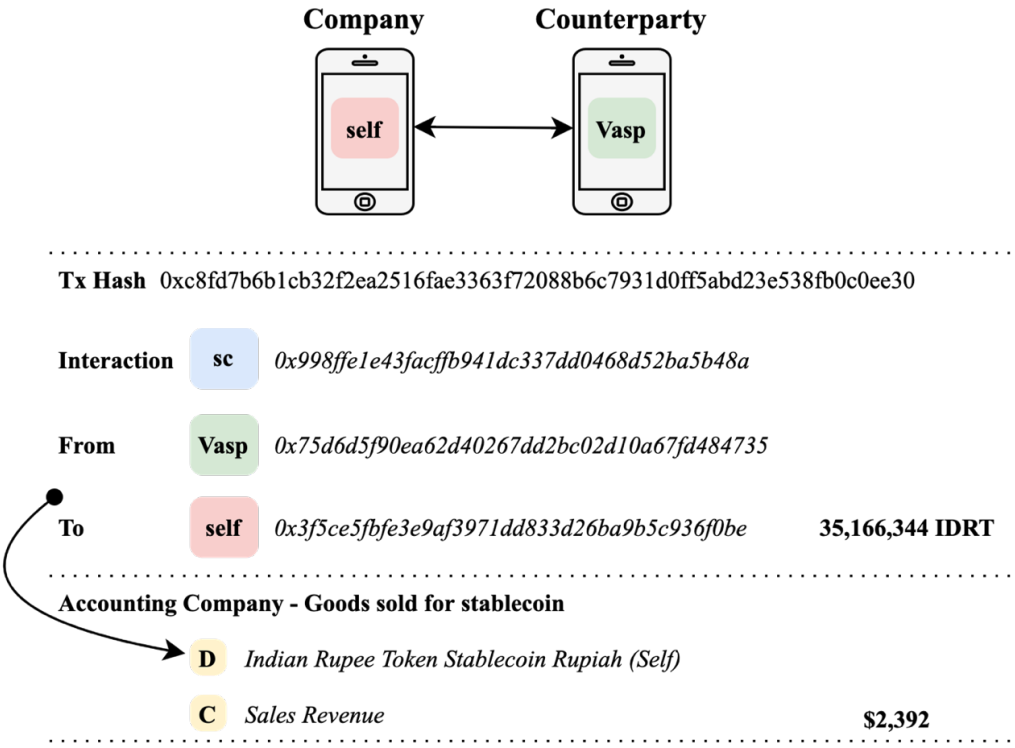

Figure 10. Self–Vasp Example
Source: Authors' elaboration based on
etherscan.io/tx/0xc8fd7b6b1cb32f2ea2516fae3363f72088b6c7931d0ff5abd23e538fb0c0ee30

4.5. Self-Self

In self–self transactions, both audited and counterparty transactions move stablecoin directly via peer-to-peer networks without the intervention of a Vasp or DeFi intermediaries. This type of transfer makes it impossible to confirm the counterparty's identity through an intermediary unless the payment is related to a transaction with assets registered in an off-chain ledger. The register in the

blockchain reduces the risk of auditing in the analysis of the direct stablecoin transactions between the company and a counterparty. Different from the money in 'hand–hand' transactions, in 'self–self" transactions, there is a ledger (blockchain) to control transfers of the stablecoin. Although not referring to stablecoin, the example in Figure 1 on cryptocurrency bitcoin is relevant here, whereas the parties to the transaction (the company and the counterparty) have their wallets.

4.6. Self-DeFi

The modality Self–DeFi refers to a business agreement between the company and a DeFi registered in one transaction. Unlike other types of transactions, in which there are interactions between a company and its counterparty, in the Self–DeFi examples shown in Figures 11 and 12, the company trades with a 'contract', similar to intrabank operations. Transactions originating from the interaction with DeFi can facilitate the reconciliation of transactions conducted in DeFi with the accounting record, as with services traded in financial institutions or on stock exchanges. For example, a stablecoin borrow obtained at a DeFi can be recorded as a borrow (liability) in the company's accounting.

In this scenario, shown in Figure 11, the company (0xdbf664947) interacts with the contract (0x398ec7346d) of the DeFi called AAVE, deposits 30 WBTC to a contract (0x3dfd23a6c) also of the AAVE, receives 30 aWBTC (aave interest-bearing WBTC) representing a deposit receipt in the value of $797,659.53.

In these examples, the complexity in the blockchain and smart contract system is evident, since the 30 aWBTC represents a 30 WBTC deposit in AAVE, and 30 WBTC represents 30 BTC wrapped by the DeFi Wrapped Bitcoin, so that these bitcoins, from the Bitcoin blockchain network, transit through the Ethereum blockchain network. In these mutations, there can be gains or losses, because, usually, the prices of BTC, WBTC and aWBTC are different. In this example, there was a loss of $23,640.88. In addition, the company earns interest in WBTC from its deposit in the contract.

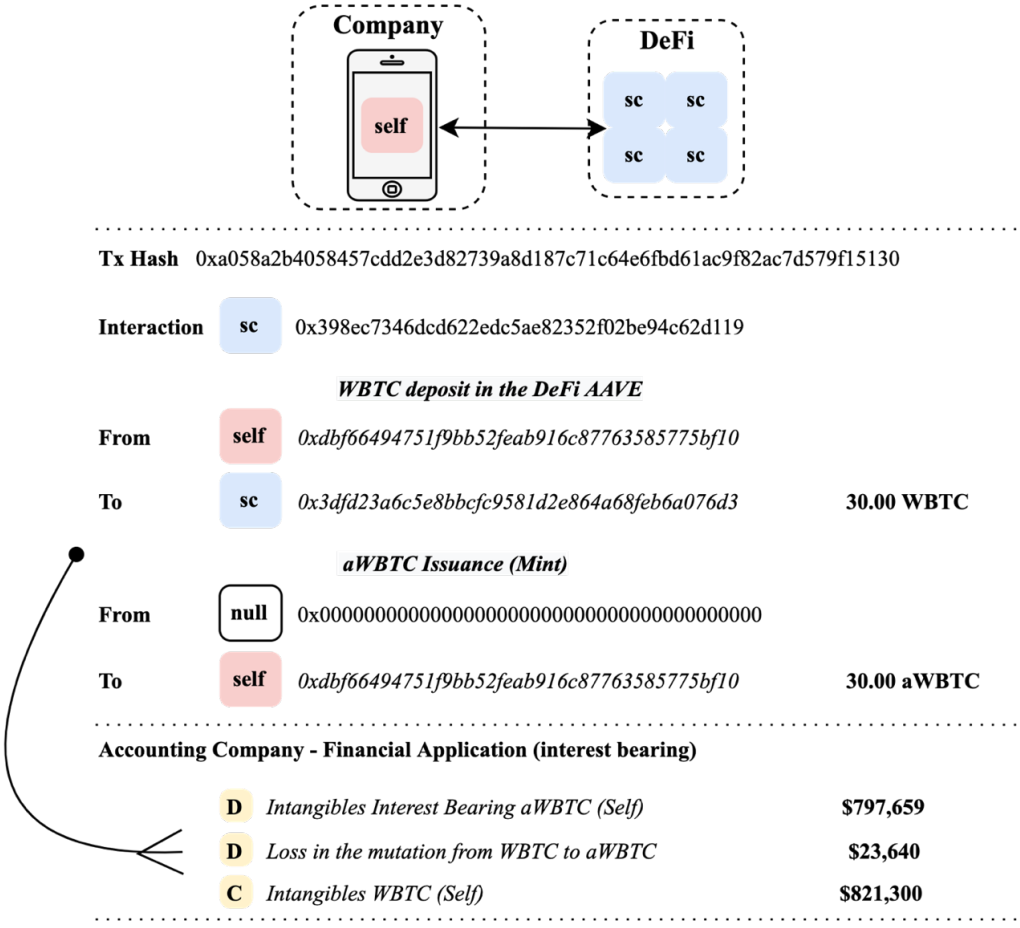

Figure 11. Self–DeFi example I
Source: Authors' elaboration based on
etherscan.io/tx/0xa058a2b4058457cdd2e3d82739a8d187c71c64e6fbd61ac9f82ac7d579f15130

In sequence, as shown in Figure 12, the same 30 WBTC served as collateral for obtaining a 200,000 USDT (fiat-backed stablecoin) loan in the AAVE. The amount of 200,000 USDT comes from USDT deposits previously made by network participants in the AAVE. The patrimonial controller (contract) of the USDT internally transfers stablecoins from the AAVE contract to the public key of the company. The company will pay interest in USDT on its loans.

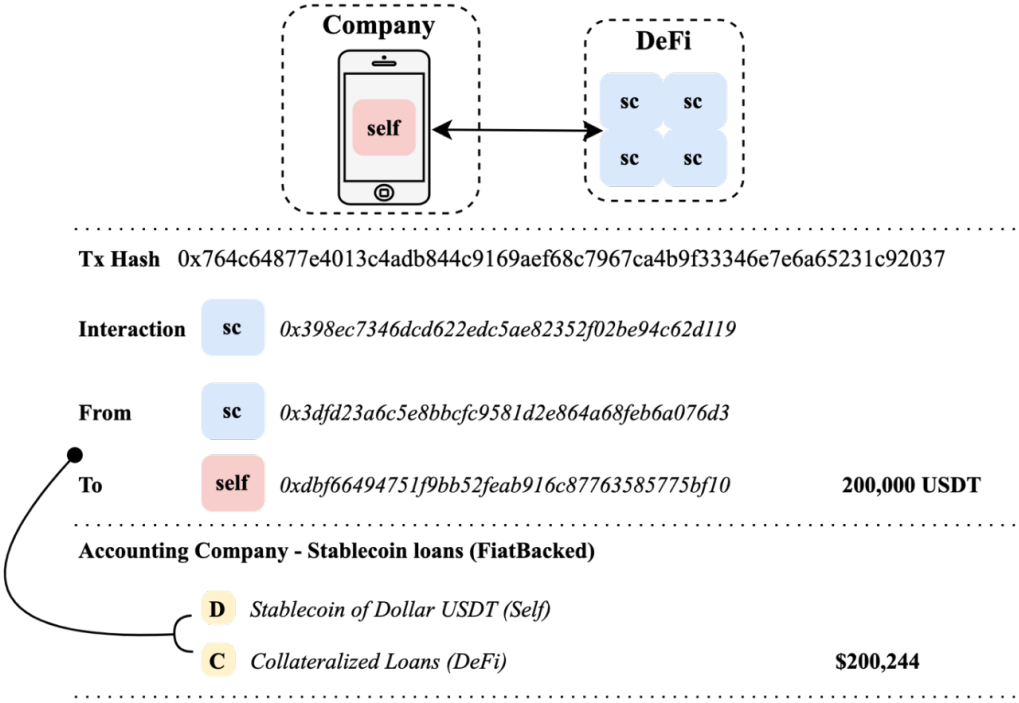

Figure 12. Self–DeFi example II
Source: Authors' elaboration based on
etherscan.io/tx/0x764c64877e4013c4adb844c9169aef68c7967ca4b9f33346e7e6a65231c92037

These examples show the potential past and future journeys of 200,000 USDT. We can ascertain from etherscan.io that the owner transferred half of the 200,000 USDT to public key 0x0867a633b as per transaction 0x45648a4a28c and that the 30 WBTC, which served as collateral for the 200,000 USDT loan, originated from public key 0xc868d439 as per transaction 0x9584d7099e. The information that the public key (0xdbf664947) belongs to the audited company enables the auditor to access the history of rights and liabilities assigned to the company's wallet.

4.7. Self-MultiDeFi

We now present the example of a transaction registered in the blockchain to demonstrate the interoperability and composability of permissionless public blockchain. Interoperability is key to developing new technologies in the financial market characterised by interdependencies and network effects, and for implementing a DLT (European Central Bank, 2021). Composability 'is the degree to which an artefact is capable of being constituted by combining things, parts, or

elements' (Balci et al., 2011, p. 158). Schär (2021) emphasises that the composability inherent to a public blockchain and smart contracts allows developers to create entirely new financial instruments. In Figure 13, we denominate these transactions as Self–MultiDeFi.

In the Self–MultiDeFi transaction, a company codes a smart contract to execute various business agreements from a set of transfers of several crypto assets and stablecoins, and the interaction with one or multiple DeFis is synthesised in a single transaction built in Ethereum. The combination of operations (business agreements, DeFi, and crypto assets and stablecoin) can constitute a single commercial objective, in which the occurrence of one 'piece' in this ensemble depends on the occurrence of another 'piece'. The structured operation is executed in an atomic way: 'either all the steps are executed, or the transaction is rolled back and none of the steps take place' (Finematics, 2020). An example of a Self–MultiDeFi transaction is a 'flash loan', in which some DeFis allow the user to borrow without depositing collateral (uncollateralised loans). From one or several 'flash loans' of stablecoin and other crypto assets without a guarantee, a company executes various operations, repays the loan, secures a profit or another economic benefit (AAVE, 2021b), taking advantage of the differences in crypto asset prices across several DeFi products (Gronde, 2021).

The transaction 0xdf54c28bbc94fc, as shown in Figure 13, consisted of a borrow (flash loan) of 2.018 Ether, various operations, settling the borrowed, and profit of 255 DAI (stablecoin crypto-backed). The contract 0x7a512a3cf68df, created by the company (0x80f47e8a386e), governed these operations, which involved four crypto assets, three DeFis, and seven business agreements in a tangle of transfers.

We classified the specific transaction 0xdf54c28bb from the interoperability and composability of the blockchain network and smart contracts as a gain because there was an increase in assets without the concomitant increase in liabilities. For these new types of transactions, the auditor should establish specific procedures for each economic benefit resulting from the set of operations, based on adaptive analogies from existing procedures.

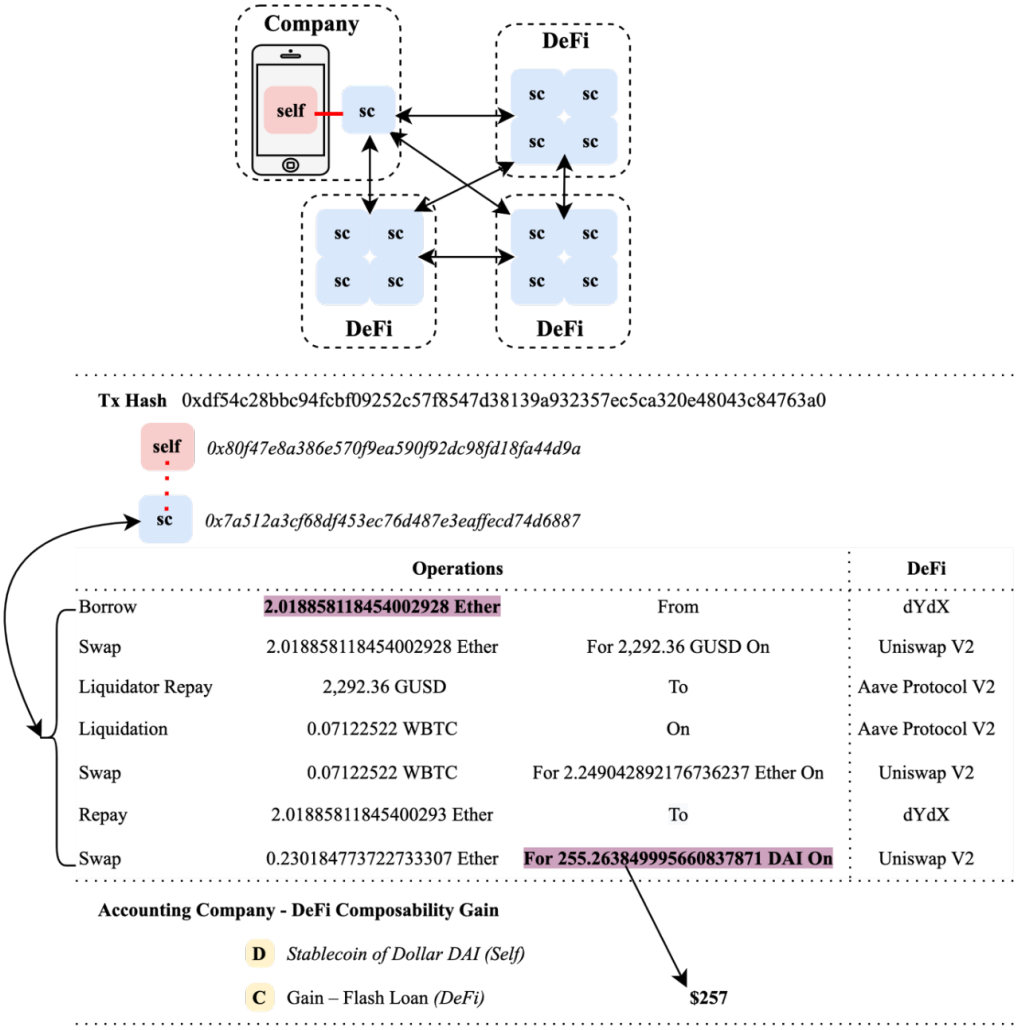

Figure 13. Self–MultiDeFi example
Source: Authors' elaboration based on
etherscan.io/tx/0xdf54c28bbc94fcbf09252c57f8547d38139a932357ec5ca320e48043c84763a0

In this example, the contracting of the debt and its extinction occur at the same moment. The auditor can mirror the gain recognition, measurement, and disclosure rules from the derecognition of financial liabilities set out in IFRS 9 – Financial Instruments (IASB, 2018b).

5. DISCUSSION AND CONCLUSIONS

Following the studies of Vincent and Wilkins (2020) and AICPA (2020), this paper discusses the accounting and audit of a new asset—stablecoin. The auditor, to form an opinion regarding compliance with accounting standards for financial statements of a company that has stablecoin balances and transactions, will establish specific procedures to obtain sufficient and appropriate evidence on the link between the balances and transactions recorded, measured, and presented in the company accounts and the corresponding entries in the blockchain (on-chain) and Vasp (off-chain). In the financial information, the company should specify who directly controls the wallet in which the company's stablecoins are registered. The auditor can, thus, identify the origin and destination of stablecoin transfers for transactions involving balances directly handled by the company or managed by a Vasp. In transactions where the payment operates independently from the business agreements that drive this payment, such as vasp-vasp, vasp-self, self-vasp and self-self, the company must identify the business agreement and the counterparty to that business agreement relating to the payment with the stablecoin.

Unlike direct transactions between a company and its counterparty, DeFi or IntraVasp transactions have two ends: the exchanged good and the means of payment—in this case, stablecoin. In the case of IntraVasp transactions that are purely off-chain, the auditor relies on the statements of the Vasp accountant to form an opinion about the financial statements of the audited company. In the case of transactions Self-DeFi or Self-MultiDeFi, which are purely on-chain, the auditor trusts the statements of the smart contracts. These transactions through a DeFi can facilitate the classification, measurement, and disclosure of assets and liabilities for the accountant and the auditor, as well as mitigate audit risk because the assertion about occurrence, completeness, accuracy, and cut-off can be automated. The auditor can automate the reading of the transactions (rights and liabilities) to confirm balances and transactions recognised in the company's accounting. The audit procedures for these businesses can emerge from blockchain technology itself, via an audit tool based on a smart contract. Rozario and Vasarhelyi (2018) describe a new era of ‘smart audit’, a series of autonomous audit procedures including autonomous internal control tests (smart control test) and autonomous analytical procedures (smart analytical procedures). However, Schmitz and Leoni (2019) find it unlikely that all transactions will be audited by smart contract and blockchain

procedures or that they will undergo automatic data reconciliation. Complex accounting entries such as fair value assessment or impairment tests require the human knowledge and judgement of accountants and auditors. In addition, given that technology is constantly changing, the speed of obsolescence of a tool or automated technique will always cause uncertainty in the realm of compliance (International Auditing and Assurance Standards Board, 2021).

Another challenge for accountants and auditors to develop new accounting rules is the continuous emergence of new assets issued from the interoperability and composability of blockchain and smart contracts. These emerging properties can enable the creation of new business agreements and financial instruments without a category fixation. Establishing a category for these new instruments is difficult for regulators and accounting professionals because they quickly form, break up, and transform into other instruments according to the conjunction of transactions and DeFi. The accountant will identify the substance of contractual rights and obligations from this interoperability and composability of DeFis, and disclose the methods, assumptions and judgements used in the identification of the item with a base in IASB (2018a, p. 38): 'the terms of the contract or a group or series of contracts require analysis to identify the substance of the rights and obligations'. Due to recurring innovation and multiplicity of the transactions, the accountant can analyse on a case-by-case basis, with the respective certification of the auditor, or create together with auditors an open universal repository with the most relevant transactions collected from the blockchain network with its semantic and empirically proven contents, like the systematic classification made by Gronde (2021). In this case, the auditor will certify these judgements through a smart audit, which will reconcile transactions recognised in the company's accounts and those registered in the repository.

Most of the existing research on this topic merely describes the characteristics of the blockchain, tries to establish the consequences of this technology for auditing and accounting, or presents designs of accounting information systems based on this technology. The lack of literature on the topic was the main limitation of our research because new themes and terms are emerging in an environment of rapid and constant change in blockchains. The researcher, accountant, auditor, and regulator exist in a society called 'liquid-modern,' where 'conditions of action and strategies designed to respond to them age quickly and become obsolete before the

actors have a chance to learn them properly' (Bauman, 2005, p. 1). Previously, the speed of birth of new financial assets and its respective categorisation was limited by the 'physical' speed of regulators, as the 'off-chain ledgers' were and are controlled by regulated entities. Now, regulators need to adapt to the speed of technological innovation. To deal with this fast-changing technological landscape, the actors need to remodel adaptation processes and the creation of audit procedures; alternatively, the social function of recognising and certifying any patrimonial position of a person, business, or institution may require the creation and development of a new profession.

It is important to note that the purpose of the article is to start a debate on stablecoin auditing, with examples of transactions registered in the blockchain. Deepening each example would require specific research into the complexity of the transactions in the example. For future research, we propose an analysis of the costs of establishing a reliable link between stablecoin and its guaranteeing assets, as well as an investigation of taxation on income from foreign exchange gains at the time of stablecoin redemption.

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