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TRIPLE-ENTRY BOOKKEEPING
A critical examination of an ostentatious accounting novelty

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Abstract

Triple-entry bookkeeping may appear as a puzzling novelty, given that classic accrual-based double-entry bookkeeping has served accounting needs well for centuries. This article critically ex-amines the evolution of triple-entry accounting proposals, beginning with Yuji Ijiri's 1980s concept of accounting for momentum and force through a genuine third ledger entry. Although his proposals failed to gain traction, the triple-entry terminology resurfaced in the early 2000s with a new focus on leveraging advancements in cryptography. The third iteration of triple-entry bookkeeping emerged around 15 years later, as proposals began to align with the blockchain trend initiated by Bitcoin and other cryptocurrencies. Despite the attractive promises of richer, decision-relevant accounting data and trustworthy, immutable ledgers, we argue that all these proposals ultimately fail to convince. Triple-entry bookkeeping has primarily functioned as a buzzword to promote novel theories or technologies rather than providing a tangible, useful advancement in accounting.

Key words: accounting theory, triple-entry accounting, bookkeeping, blockchain, cryptography

1. Introduction

Accounting involves creating a trustworthy ledger that accurately reflects past events and provides valuable information through systematic aggregation of transactional data. The basic double-entry accounting technology we use today is centuries old. Does it need an update? Perhaps better insights could be derived from processing accounting data differently? Despite stricter regulations, standardization, and auditing, accounting frauds continue to occur, often on a larger scale. Increased regulation hasn't prevented the next big fraud case. Could more reliable and trustworthy data be achieved with better accounting technology? Many improvements have been proposed, including the concept of triple-entry accounting, which has been discussed for over forty years now.

This article examines the innovations known as triple-entry bookkeeping, their purposes, and their success. The term 'triple-entry bookkeeping' or 'triple-entry accounting' has evolved significantly since it first appeared in the 1980s. Yuji Ijiri was the first to use this

term in 1982 (Ijiri, 1982). Although Ijiri's concept of momentum and force accounting attracted some academic interest, it did not gain widespread traction, leaving only the term triple-entry accounting. The recent advent of blockchain technology has revived interest in triple-entry bookkeeping, now focusing on verifiability and immutability. However, we argue this revival is largely futile due to the oracle problem; data external to the blockchain always requires trust for accurate input. Therefore, the only truly reliable immutable data is that which is internal to the blockchain, making the use case of currency and accounting for the blockchain's native token the only feasible use case. We examine whether triple-entry bookkeeping, in any of its proposed variations, has made a meaningful and lasting impact on accounting practices. Our research question is: Given the long-standing dominance of double-entry bookkeeping, what novel ideas do triple-entry accounting innovations propose, and how have these ideas been realized since the early 1980s?

Our contribution is to review the literature on the concept of triple-entry accounting and outline the evolution of the content proposed under this term at different times, which is detailed in section 2. It turns out that the term 'triple-entry bookkeeping' is largely a misnomer because only Ijiri's proposals genuinely include a third bookkeeping entry to process accounting data in a novel way. Subsequent proposals by other authors focus on making the bookkeeping documents public and presumably immutable through cryptographic security, significantly altering the meaning of 'triple-entry bookkeeping' since its inception. We trace these changes and assess their impact.

In section 3, we critically examine the three phases in the evolution of the term 'triple-entry bookkeeping' to determine whether the promises made by the authors' proposals have been fulfilled. Ultimately, we find that both the first (Ijiri) and second (Grigg and Boyle) contributions have remained largely irrelevant, and the third wave of proposals, the blockchain implementations of triple-entry accounting, prove theoretically flawed. Many academic proponents of blockchain use, such as in supply chain management or accounting, seem unaware of the oracle problem, which we discuss in that section. A major obstacle to advancement in accounting, particularly involving cryptography and blockchain, is that accountants often don't understand the computer science and cryptographic mathematics, while mathematicians and computer scientists are not fluent in accounting theory. We conclude in section 4.

2. Development of bookkeeping technology

2.1. *From single- to double-entry: From Antiquity to the Italian Renaissance*

Accounting is ancient. Single-entry accounting dates back to Mesopotamian times, evidenced by cuneiform clay tablets from Mesopotamia as far back as 3500 BC. Single-entry accounting keeps track of stocks only (assets and liability). As an asset (or a liability) enters into or disappears from a business, a recording item is added or removed to a list of assets (or liabilities). The single record implies there is no tracing of changes, making this system vulnerable to fraud or error (Mann, 1994; Mattessich, 1994). This deficit of just writing down "what is" caused a fermenting search for better solutions among merchant scholars globally.

While everyone in the field has heard of Luca Pacioli, revered as 'father of bookkeeping', many commercially active world regions, notably in the East, developed forms of double

entry bookkeeping since antiquity (Jun et al., 2013; Mattessich, 2000; Nigam, 1986; Sangster, 2016). Luca Pacioli certainly was not the inventor of double-entry bookkeeping, but made his name famous as the first author to publish the then widely used double-entry bookkeeping system, by including it in a comprehensive compendium of contemporary mathematics *Summa de Arithmetica* (Pacioli, 1494). A strong contender for the 'father of accounting' honorific is the Croatian-Italian merchant, scholar, and diplomat Benko Kotruljić, also known as Benedetto Cotrugli, the Italian variant of his name. He beat Pacioli by several decades by including a description of double-entry bookkeeping in his 1458 manuscript *Della mercatura et del mercante perfetto,* which survives in a 1475 copy, but was only published in print about a century later (Cotrugli, 1458, 1573; Sangster & Rossi, 2018; Skuhala Karasman, 2022).

Hence, it is safe to claim that double-entry bookkeeping has been a cornerstone of Western commerce since the Renaissance. The technique provides a robust framework for accurate financial reporting and fraud prevention. The system maintains an audit trail by ensuring that all debit balances equal credit balances, enabling errors to be traced back to their original entries and source documents. This dual recording acts as a safeguard against both accidental and intentional errors, a feature absent in single-entry bookkeeping (Cai, 2021, p. 75).

Given the substantial leap from single to double-entry bookkeeping, it is logical to consider further advancements in bookkeeping technology. There are certainly aspects of bookkeeping that could be improved: Even if all debits equal credits, the formally correct result does not guarantee that the correct accounts were chosen, leading to misleading reporting. Furthermore, each firm records its transactions independently from its transactional partner(s), allowing for the fabrication of fictional transactions. Traditionally, this deficit is mitigated through 'independent' external auditors, who are supposed to ensure the integrity of financial information. However, accounting and auditing are costly, time-consuming, and still insufficient to prevent fraud, as seen in regular accounting scandals of increasing magnitude. In reality, only a small sample of a firm's transactions can reasonably be expected to be audited (Cai, 2021, pp. 71, 75).

In the following section, we distinguish three variations of triple-entry bookkeeping concepts proposed in the late 20th and early 21st centuries. The first attempt was Ijiri's momentum accounting of the 1980s, which aimed to track the rates of change in certain accounts to provide more relevant information. Later, the advent of computer-based cryptography led to the development of the digitally signed receipt, promoted by Grigg and Boyle in the late 1990s and early 2000s as a new interpretation of triple-entry bookkeeping. More recently, the integration of blockchain technology has spurred interest in using a decentralized ledger to store accounting information, driven by the innovation of Bitcoin and other cryptocurrencies. These three phases will be subsequently laid out (section 2.2) and critically examined (section 3).

2.2. *The triple-entry innovation attempts of the 20th and 21st century*

2.2.1. Triple-entry accounting to extract more information

Yuji Ijiri introduced the term 'triple-entry' into bookkeeping with the intention of extracting an additional layer of information from the double-entry system. His concepts were first presented in a short 1982 monograph, followed up by a summary article four years later

(Ijiri, 1982, 1986). Ijiri's approach aimed to advance accrual accounting technique to go beyond recording assets and liabilities and explain changes in net worth through revenues and expenses. He sought to take the traditional approach one step further, akin to the logic of calculus, by examining the rate of change of a variable and subsequently the change of that rate, in successive derivations. Ijiri called this approach *momentum accounting,* which suggests a parallel to descriptive statistics, which describe qualities of distributions through their momenta (mean, variance, skewness, kurtosis, see e.g. Hamilton, 1994).

Ijiri defined the rate of change at which income is earned as *momentum*, expressed in monetary units per period. The third-level entry, defined through a set of *trebit* entries on *force* accounts – a term modeled after the traditional *debit* and *credit* entries–, records changes in momentum, offering a more nuanced view of an organization's financial dynamics (Ijiri, 1986, p. 749). His primary objective was to direct management's attention to deeper factors beyond wealth and income, which are traditionally addressed by double-entry bookkeeping (Ijiri, 1986, p. 745). By introducing momentum accounting, Ijiri aimed to enhance the informational value of financial statements, allowing for a more comprehensive understanding of the economic forces within an organization. Consequently, he redefined financial statements into the wealth statement, momentum statement, and force statement. This approach represented an original theoretical novelty in accounting, though its practical adoption, to be examined in section 3.1, has been rather limited.

2.2.2. Triple-entry accounting using digitally signed receipts

Even if Ijiri's theoretical proposal did not resonate much in academia or the accounting field, the term he established, 'triple-entry accounting,' soon revived in the literature with a different meaning. The second iteration of triple-entry accounting aimed to create a connection between the books of two companies involved in a transaction to make accounting records more trustworthy and less susceptible to fraud. Accounting ledgers, which must be free from fraud or tampering to retain credibility, are always under the exclusive control of the bookkeeping entity, usually a company. In this context, the 'triple' part of triple-entry accounting refers to cryptographic links with digitally signed receipts between the two sets of books affected by any inter-company transaction, essentially creating a shared record of the transaction between contracting companies. While this connection already exists through traditional means like invoices, the digital signature approach aims to enhance trust and reduce fraud (Systems Innovation, 2018). Mistrust in traditional accounting often stems from discrepancies between the seller's and buyer's accounts. Thus, the 'third' entry is now redefied as a digitally signed receipt that cryptographically seals the transaction record, making falsification purportedly impossible.

Proponents of digitally signed receipt-based triple-entry accounting prominently include Ian Grigg and Todd Boyle. Their cryptographically-driven solutions trace back to Grigg's 2005 working paper, formally published in 2024 (Grigg, 2005, 2024), and to Boyle, a practitioner who published various implementation concepts (Boyle, 2001a, 2001b). Their publications do not yet mention blockchain storage. Rather, Grigg proposes a cryptographic server as a middleman for all transactions, producing and backing up a

digitally signed receipt for each transaction. However, his proposal does not address who would act as the trusted, neutral third party to control this shared ledger.

Such digitally signed solutions became practically feasible through advancements in cryptography in the 1970s and 1980s, such as public key cryptography and the increasing availability of computing power (Chaum, 1979, 1981; Diffie & Hellman, 1976a, 1976b; Rivest et al., 1978; Zimmermann, 1991). As an aside, these advancements also laid the groundwork for the invention of Bitcoin and subsequent blockchain-based triple-entry solutions, which will be explored in the third incarnation of triple-entry accounting. Grigg suggested that the digitally signed receipt be a *Ricardian* contract, legible by both humans and computer programs, allowing for automated execution (Grigg, 2005). In this way, Grigg anticipated concepts that would later become feasible with smart contracts on blockchain-based protocols, as discussed in section 2.2.3.

2.2.3. Triple-entry accounting with blockchain storage

The triple-entry innovation wave gained new vigor with the proliferation of blockchain technology from the mid-2010s on. Blockchain appeared to offer a significant improvement by enabling the third entry to be decentralized and immutably stored 'on the blockchain.' This development aligned with the ongoing trend of tightening legal reporting requirements and increasing accountability for accountants and auditors following critical events (McClelland & Stanton, 2004; Staubus, 2010). Cryptographically secured documents, as discussed in the previous section, were an initial attempt to enhance data security in accounting, and blockchain technology now promised further improvements. Both digitally signed receipts and the subsequent blockchain-based accounting owe their existence to breakthrough inventions in cryptography, such as public key cryptography and cryptographically secure hash functions (Liu et al., 2024; Wirdum, 2023, Chapter 4). The advent of blockchain has been the most powerful driver behind the renewed push for triple-entry accounting, as evidenced by the vast amount of literature, both academic and practical: Dissemination of research and opinions has never been easier than now, compared to Ijiri's 1980s or Grigg and Boyle's early 2000s. Industry reports from Deloitte and PricewaterhouseCoopers in 2015 and 2016 reflected this enthusiasm and great optimism about blockchain's potential (Deloitte, 2016; PricewaterhouseCoopers, 2015, 2016).

While blockchain technology had been discussed academically as early as 1979 (Chaum, 1979; Haber & Stornetta, 1991; Konst, 2000), its practical applications expanded rapidly only post-2009 with the cryptocurrencies. But an early use case of blockchain addressed the need for immutable storage of digital information, proposed by Haber and Stornetta in 1991 (Haber & Stornetta, 1991). They suggested time-stamping the metadata of any digital information as proof of when the data was created or last modified, using cryptographic hash functions and chaining the information together like a 'sewn-together lab notebook'—the first practical application of blockchain data storage after Chaum's initial concept proposal from 1979.

The preeminent use case of blockchain data storage began with the inception of Bitcoin in 2009 and the subsequent popularization of numerous copycat cryptocurrencies. Using the model of cryptocurrency accounting on blockchain, a new wave of innovation in commercial accounting followed, some of which sailed under the banner of triple-entry

accounting. A blockchain is distinct from traditional centralized databases, composed of data blocks that are back-linked and append-only. Assuming a suitable consensus mechanism, a blockchain doesn't require an administrator. An instructive analogy is geological layers that become more stable the deeper you go, eventually becoming an immutable snapshot of the past (Antonopoulos & Harding, 2023, Chapter 11). The usability for immutable storage has been obvious since 1991 and using a blockchain for accounting seemed a natural extension of time-stamping. Bitcoin, the flagship implementation of blockchain accounting, popularized accounting data storage in sequentially linked form, made immutable by Proof-of-Work consensus. This naturally led to the idea of using a public blockchain for commercial accounting, thus sparking the third and latest wave of triple-entry accounting proposals.

When this blockchain ledger is distributed among many participants, it is already considered immutable by the casual observer. Blockchain-based triple-entry proposals are abundant in the literature but often lack detail. Advocates like Dai and Vasarhelyi (2017) describe blockchain storage as a novel accounting database that records transactions in linear chronological blocks shared across a network. They outline the evolution of blockchain phases descriptively and provide extensive illustrations of triple-entry accounting in smart contracts, yet remain vague about the specifics of blockchain implementation. Similarly, Septiawan and Fartika, as well as Bhayangkara et al. offer only a broad sketch, stating that transactions "will be recorded on the blockchain ledger" and suggesting the use of bank-mediated tokens for payments without even detailing the nature of such tokens (Bhayangkara et al., 2024, pp. 635–638; Septiawan & Fartika, 2022, p. 45). Tyra (2023) pioneered the integration of cryptographically signed receipts with blockchain technology, connecting Grigg's idea with blockchain storage. Ibañez et al. follow up and present a comprehensive synthesis of Grigg and Boyle's earlier triple-entry proposals within the context of newer blockchain concepts (Ibañez et al., 2023, pp. 3–5).

While the term 'blockchain' has become central to this development, it is important to recognize that many more components enable – and are necessary for – true decentralized immutability in a blockchain-based system. Notably, the consensus mechanism, which determines who may attach new blocks of data, is crucial as it also reveals who might be able to (partially) rewrite a blockchain. Cryptocurrencies are hardly limited to 'the blockchain', but are complex systems that depend on many components functioning together. We will revisit this question of complexity in section 3.3.

3. Critical examination of triple entry accounting proposals

After the previous section outlined the evolution of triple-entry accounting over the past four decades, this section critiques the proposals and examines their usefulness and practical significance.

3.1. *Ijiri's triple-entry bookkeeping using force and momentum*

Ijiri essentially proposed a valid and feasible system of *differential* triple-entry bookkeeping, while rejecting the variant of *temporal* triple-entry on the grounds of false assumptions (Ijiri, 1982, pp. 16–17). In his differential triple-entry system, the two traditional bookkeeping entries are conceptualized as capital and wealth, while the third entry, named *force*, aims to explain the reasons for changes in income *momentum*—the

firm's ability to continue generating income. He develops the coherent concept of a third basic accounting statement growing out of this analogy. A balance sheet is a summary of wealth, an income statement is a summary of changes in wealth, and a force statement would be a summary of changes in the rate at which income is earned. The new force statement shows the rate of change in income in terms of the dynamic concepts momentum, friction, and decay, regarding individual cost and revenue components. In the contemporary reviewer's opinion, this concept is clearly a powerful extension of the variance analysis idea. (Shank, 1983, p. 656). The new triple-entry accounting equation, therefore, turns into Wealth = Income (or Capital) = Force. Capital and force are integrated, tracing back to the same wealth that needs to be accounted for. Consequently, a trial balance in such a system would contain three columns (Fraser, 1993, p. 151; Ijiri, 1982, pp. 19–25).

Ijiri's triple-entry accounting proposals generated fairly little discussion in the literature over the 1980s and 1990s and are mostly remembered today for its keen originality, as well as the memorable 'triple-entry bookkeeping' term. Fraser's critique highlights the major flaw: Ijiri's differential triple-entry proposal fails to consider the objectives of, and the need for, extending double-entry bookkeeping. Ijiri does not convincingly argue that a third dimension of accounting is necessary. Instead, the usefulness of his differential triple-entry system is only considered ex post after it has been developed. Ijiri justifies his proposal on purely logical grounds rather than on practical utility, providing no clear reason or need that would demonstrate the proposal's usefulness (Fraser, 1993, p. 152).

Another valid point of criticism is that Ijiri's equalization of wealth with income, along with using income and capital as synonyms, contradicts the commonly understood meanings of these terms (Fraser, 1993, p. 154). This arbitrary and unconvincing choice of terminology further weakens Ijiri's proposal. Contemporary reviews of his monograph were politely skeptical about his theory-laden highly unconventional approach of *force* accounts and *trebit* entries: "Whether Ijiri's ideas … will revolutionize accounting thinking is subject to question" (Shank, 1983, p. 656). From today's perspective, Ijiri's triple-entry bookkeeping failed the test of time and seems a solution in search of a problem. Consequently, the concept of triple-entry bookkeeping fell dormant until Grigg, Boyle, and others revived the term with new content about two decades later.

3.2. *Grigg and Boyle and triple-entry accounting with digital signature receipts*

Boyle and Grigg reinterpret triple-entry accounting based on a shared digitally signed receipt as the centerpiece linking the two ends of a transaction. Their mantra is that 'the receipt is the transaction,' which has arguably always been true in financial accounting, where generally accepted accounting principles require evidence of the transaction being booked (as per basic accounting principles, see e.g. Kieso et al., 2019, Chapter 2).

A significant deficiency of the Grigg/Boyle proposals is that the nature or practical implementation of the third, shared ledger is never operationally explained. Important questions remain unanswered: Who, or what institution, would run this ledger? How would they be incentivized to do so? Most importantly, why should they be trusted, given they have full control over the centralized database of digital signature receipts? Even if the receipt itself cannot be altered, it could be replaced if all involved parties colluded—who would then prevent such collusion? This raises doubts about whether this approach truly

represents an advancement in safeguarding accounting data, as the responsibility for data protection rests with a single entity, with no credible obstacle to collusive fraud.

Grigg concedes that the triple-entry aspect of his proposal is not so much the revolutionary improvement which the avant-garde triple-entry accounting term might suggest, but considers it just a modest "advancement" (2024, p. 7). This advancement comes at a significant administrative cost of three entries for each single transaction—two at the transacting parties and one at the issuer of the digital document. Thus, four entries (or two double-entries) become nine (three triple-entries), multiplied by millions for real business situations.

The question of interoperability is not addressed. Accessibility to any participant is a major advantage of a public decentralized blockchain data storage. However, Grigg and Boyle envision proprietary solutions (Grigg, 2024, p. 10), which could provoke resistance to locking a company into one provider and raise questions about how a proprietary data storage, blockchain or otherwise, could be credibly and immutably secured. Grigg has proposed this same solution in an informally published paper two decades earlier (2005), and references implementation attempts from as early as 2003. The fact that he formally published the essentially unchanged article again in 2024 does not suggest a dynamic development in the triple-entry accounting field after Ijiri.

Both Boyle and Grigg approach triple-entry accounting from a software programmer's perspective. While they go into great detail describing database structures and storage concepts for all involved parties, the question of data immutability is not discussed at a deeper level. This is surprising, given that data security was the initial motivation of their proposals. Their concepts are driven by design proposals for data storage for accounting ledgers, but reveal a lack of basic accounting know-how. Grigg considers Boyle's observation that for every trade record in one firm, there must be a matching record in the other firm—but "why can't they be the same?" In reality, they typically are the same. For example, one firm's outgoing invoice evidencing a sale is identical with the receiving firm's incoming invoice that evidences their increase of inventory. Grigg understands this, as shown in his examples: An outgoing invoice by 'Alice' is posted to her General Ledger Transactions (GLT), digitally signed by the middleman service provider, and forwarded to buyer 'Bob.' The advantage of signed receipts in Grigg's concept is the digital signature's evidentiary power and the concordance among the three parties. However, this is hardly a challenge to the "500-year reign of double entry" (Grigg, 2024, p. 10). It is merely an improvement over the paper or electronic document form that has always been the basis of classic double-entry bookkeeping. Grigg concludes that the triple-entry concept is no replacement for the convenience and local cross-check of debit-credit double entries. He admits that accounts are "much harder" to change (2024, p. 10), but this falls short of true immutability that a credibly secured blockchain solution might provide.

So, the 'third' entry in this approach is effectively just a link between the sets of books of two companies for a specific transaction, rather than an additional accounting entry that processes data in a new way. Hence, the term 'triple-entry' is misleading because it does not create a new entry but simply links two traditional double entries. Proponents claim that this link acts as a tamper-proof smart contract, but this claim is contentious as it introduces security risks. Businesses typically wish to keep their accounting figures

confidential, and storing information on a server of digitally signed receipts operated as a separate service could become a target for hacking, posing transparency and security challenges.

3.3. *Blockchain-based triple-entry accounting*

There are two main points of criticism towards blockchain-based triple-entry accounting is the illusion of blockchain immutability and obliviousness to the oracle problem of external data on the blockchain.

Blockchain immutability. The problem with blockchain-based accounting is that its proponents often isolate one aspect of a complex system—the blockchain—without considering all other system components that make the system work as a whole. The immutability of Bitcoin's blockchain, as the most prominent and indisputably immutable blockchain, comes from the combination of the data structure and the Proof-of-Work (PoW) consensus mechanism (Antonopoulos & Harding, 2023, Chapter 12). An apt analogy is the organs of a body making up a functioning organism. Neither the heart nor the liver alone makes a living organism; all organs must work in harmony for the organism to function properly. Security in a blockchain system originates not just from using cryptographic tools and from distributing the ledger to many participants, but from embedding it in a framework where the consensus mechanism prevents any individual from controlling, appending, or possibly rewriting part of it. Tyra (2023) claims that triple-entry accounting is possible on a modified Bitcoin infrastructure but fails to provide details. This raises the issue of how anyone would reliably benefit from the enhanced trustworthiness and how this claim is substantiated.

This misunderstanding stems from a lack of knowledge about deployed blockchains. Cryptocurrencies are the only practical application of blockchain because they can pay for their own security according to the chosen consensus mechanism with their native tokens, provided these tokens have acquired value in a successful bootstrap. Consequently, their accounting needs are confined to information *inherent* to their blockchain. When a blockchain tries to account for external value, such as supply chain logistics or fiat currency payments, the question arises: who inputs this external information onto the blockchain? Trusting a blockchain operator to input accurate data is no different from trusting the issuer of traditional booking documents, see the following subsection.

Regarding immutability, even a proof-of-work secured blockchain cannot be relied upon without sufficient PoW securing the chain. Rollbacks are possible even in weak PoW consensus, as prominently seen in the Ethereum DAO hack in 2016 (Mehar et al., 2019, pp. 24–27). A DAO (digital autonomous organization) is essentially the system behind a blockchain implementation. In case of a decentralized, distributed permissionless blockchain, this system is necessarily autonomous (Hude et al., 2023, pp. 197–198). In the 2016 DAO hack, a vulnerability allowed an attacker to drain funds, which led the (not anonymous) DAO to initiate a rollback of the ostensibly immutable transactions and caused a fork between the new chain, thereafter called Ethereum, and the previous one, renamed to Ethereum Classic (Mehar et al., 2019). Song cleverly compares exploiting such smart contract vulnerabilities to CPAs finding tax loopholes. The intractable problem remains linking real-world assets to digital records. Real assets are regulated by legal jurisdictions, therefore trust in the legal system is necessary. Possession of a smart contract or digitally

signed receipt suffers from the same trust issues as any real-world contract. Likewise, a smart contract that trusts a third party removes the feature of trustlessness (Song, 2018).

While a Grigg-style triple-entry accounting system could be made compatible with blockchain, the problem is that blockchain storage is less secure and immutable than its proponents seem to believe. The core idea of blockchain triple-accounting is to 'put contracts on the blockchain', as unchangeable evidence of transactions, presumably under the classic PoW consensus. The means of how this should be achieved, however, is not well explained by blockchain accounting authors (Bhayangkara et al., 2024; Dai & Vasarhelyi, 2017; Ibañez et al., 2023). There is no convincing answer as to how PoW would be provided, who would have the incentive to provide it, and how it would be distributed. Securing ledgers with PoW is unlikely to be an activity of interest except to large companies. A weak PoW system might devolve into a Proof-of-Stake (PoS) system, where immutability is questionable due to the control of major players and the inevitable centralization (Ouyang et al., 2021, pp. 60–61). Hence, a major shortcoming of blockchain-based triple-entry accounting proposals is the securing of the blockchain. It is assumed to be sufficiently immutable when distributed to many participants, but the consensus rules determining who can append to the blockchain are neglected. Those who can write to the blockchain can also rewrite it, undermining the presumed immutability.

The oracle problem and trust. The rationale behind advocating blockchain-based triple-entry accounting was to ensure data integrity. However, when external data is entered onto the blockchain, nothing is gained over traditional accounting; the data's integrity still relies on the trustworthiness of the person who entered it. For example, recording a shipment of goods on a blockchain ledger is no more reliable than using paper or another electronic database if the operator who entered the data is not trustworthy. Nothing prevents the blockchain from being wrong about this shipment; only blockchain-native token data (the units of cryptocurrency) are reliably authentic. This makes blockchains suitable for cryptocurrencies but *not* for accounting of external business transactions, contracts, supply chain data, or similar applications. There is no compelling reason to trust blockchain information more than the same information on any other medium, whether a centrally managed database, an email, or a telefax. This issue of external data on the blockchain is known as the oracle problem. In Greek mythology, the oracle could see the future by communicating with the gods. The blockchain which exists only in the digital realm, is 'blind' and oblivious to the real word without the help of an oracle. The oracle thus must provide any real-world information to the blockchain, like stock prices, weather events, contract or transaction data, which are all external to the blockchain itself (Caldarelli et al., 2020; Caldarelli & Ellul, 2021; Teoh, 2023). Consequently, the oracle problem poses a major challenge to the promised trustworthiness of blockchain accounting records.

4. Conclusion

We conclude that the contributions of Ijiri, Boyle, and Grigg have largely remained irrelevant, and the blockchain-based approaches to triple-entry accounting are impractical. Neither the second phase (digital signature receipts) nor the third phase (blockchain) of triple-entry accounting proposals truly embody the concept of a third bookkeeping entry. Some rightly refer to it simply as 'blockchain accounting' without the triple-entry embellishment (Pflueger et al., 2022).

Only Ijiri's proposals genuinely deserve the name triple-entry bookkeeping. Out of all three variations of triple-entry accounting discussed here, Ijiri's is theoretically the most compelling. While single-entry bookkeeping is simply a list of things owned and owed, without income statements, double-entry bookkeeping introduces the income statement, which is akin to the differential of two balance sheets. Ijiri proposed a further differential as momentum, analyzing whether changes in revenues, expenses, assets, and liabilities are increasing or decreasing. Yet despite its innovative approach, his method did not turn into a convincing use case; possibly partly because evaluation methods of accounting data have greatly improved with digitalization of accounting (IFRS, n.d.) compared to the 1980s.

Triple-entry accounting, especially in its newest, currently discussed form of blockchain accounting, has strayed far from its original meaning. It is likely that blockchain-based triple-entry accounting will fall into oblivion due to the lack of credible benefits, as its immutability promise lacks in delivery. Even the most comprehensive literature reviews concede that triple-entry accounting is not yet used in practice. These studies find a wealth of literature praising its potential and providing high-level proposals, but they admit that many practical implementation questions remain unresolved (Thies et al., 2023, pp. 104, 109–110).

Because of the oracle problem, blockchain technology only makes sense for decentralized currency ledger, where the ledger accounts for itself in units intrinsic to its blockchain, in native tokens. Bitcoin, for example, is immutable money based on sound accounting principles (Nakamoto, 2008). Applying blockchain to non-monetary assets, like the proverbial 'bananas on the blockchain,' is impractical because it relies on trusting the person inputting the data, which does not guarantee the existence of the asset at any point.

One key reason for the lack of development in blockchain accounting is the knowledge gap between blockchain developers and accounting experts. Blockchain enthusiasts often overlook the limitations of their proposals and fail to address how the promised security of a blockchain-secured accounting foundation can be guaranteed (Cai, 2021, p. 73). This disconnect is evident in the ongoing debates and unresolved issues surrounding triple-entry accounting on a blockchain.

The final verdict is that triple-entry bookkeeping, in any of its forms, fails to present a substantial novelty and instead functions as a slick buzzword. It draws attention to technologies that have not convincingly improved upon basic double-entry bookkeeping from a technical perspective. In particular, cryptographically or blockchain-oriented methods of triple-entry accounting serve more as marketing tools than as meaningful accounting innovations. While there has been progress in computation, automation, communication, and reporting, there have been no significant advancements in the accrual concept of measuring changes in net worth or in making general commercial accounting convincingly immutable, as achieved for its native bitcoin token by the Bitcoin blockchain.

Goethe's accolade on double-entry, likely the favorite epigraph in the accounting profession, remains undefeated: *Welche Vorteile gewährt die doppelte Buchhaltung dem Kaufmanne! Es ist eine der schönsten Erfindungen des menschlichen Geistes* (J. W. v. Goethe, *Wilhelm Meisters Lehrjahre,* Book 1, Chapter 10). It will be a while before the *belles lettres* will swoon over triple-entry bookkeeping – if ever.

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