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Petratos, P.

Original citation:
Petratos, P 2024, 'Triple-Entry Accounting and System Integration', Journal of Risk and Financial Management, vol. 17, no. 2, 17020045 .
https://doi.org/10.3390/jrfm17020045

DOI 10.3390/jrfm17020045
ISSN 1911-8066
ESSN 1911-8074

Publisher: MDPI

Journal of
Risk and Financial Management

MDPI

Article

Triple-Entry Accounting and System Integration

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Abstract: Triple Entry Accounting (TEA) provides an opportunity for fundamental change in accounting. TEA is a foundational development of Blockchain technology, which is considered a pillar of the Fourth Industrial Revolution. Nevertheless, in order to augment its impact, TEA should be integrated with other systems. This paper aims to examine the relationship of TEA with system integration (SI) and how it can affect integration. This study reviews the SI literature in the context of accounting, examines how the literature on TEA has evolved over the years, and finally contributes to the analysis of how TEA is related to integration. A key theme is the connection of accounting controls and system integration. The methodology of the four design principles of control in system integration is adopted. Transparency is the main perspective of these principles. It was found that TEA promotes transparency, reduces the risk of fraud, and facilitates system integration.

Keywords: Triple-Entry Accounting (TEA); system integration; transparency; controls

1. Introduction

'The Fourth Industrial Revolution represents a fundamental change in the way we live, work. . .enabled by extraordinary technology advances. . .merging the physical, digital and biological worlds in ways that create both huge promise and potential peril'. (World Economic Forum 2024a). To facilitate the merger of various elements, integration is essential. Despite this promise, and while many companies are piloting technology initiatives, only a few companies have managed to integrate Fourth Industrial Revolution technologies (World Economic Forum 2019). The World Bank (2019) has called Blockchain a pillar of the Fourth Industrial Revolution. Blockchain has also evolved into a foundational technology with promising applications in many areas, enabling greater transparency and trust (World Economic Forum 2024b).

At the same time, double-entry accounting (DEA) is seen as the foundational technology of our society used for transparent outcomes (Porras 2023). Fraud is becoming more sophisticated, and fraudulent activity has significantly increased. Blockchain and, more specifically, Triple-Entry Accounting (TEA), can enhance transparency and reduce fraud. 'TEA is also a foundational contribution to the development of blockchain technologies' (Porras 2023) and can be considered a foundational technology for the Fourth Industrial Revolution. TEA could facilitate integration, and merge with different systems in order to further promote transparency. Our paper examines the relationship between TEA and system integration. An examination of this relationship is conducted through a perspective focusing mainly on transparency. This perspective assists in establishing the following secondary objective: how TEA can increase transparency and reduce fraud because of SI.

The paper can be separated into three main parts. Firstly, we contribute by providing a short review of the definitions and characteristics of system integration (SI), mainly in the context of accounting. Accounting control, systems of systems integration and integrated management systems related to ERPs and other systems are presented. This is essential because the objective is to highlight and justify the connection between accounting control and system integration. Control is, therefore, discussed in relation to SI, and four generic principles are used based on Adler and Borys (1996) and Chapman and Kihn (2009). Through these methods, we justify that these principles are adopted for two main reasons,

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Citation: Petratos, Pythagoras. 2024. Triple-Entry Accounting and System Integration. *Journal of Risk and Financial Management* 17: 45. https://doi.org/10.3390/jrfm17020045

Academic Editor: Svetlozar (Zari) Rachev

Received: 20 November 2023
Revised: 9 January 2024
Accepted: 18 January 2024
Published: 25 January 2024

they define integration in the context of enterprise and accounting, and due to the fact that the four design principles are directly related to transparency, which is the key perspective.

The second part of this paper focuses on TEA and how the literature has evolved over the years. More specifically, we focus on the standards, laws, and regulations that encourage controls, with the notable example of the Sarbanes–Oxley Act (SOX) analyzed. Controls can increase transparency and reduce the risk of fraud. Hence, accounting controls remain the main narrative that aligns different parts of the paper. The history of accounting, from Triple-Entry Bookkeeping to the application of Blockchain and the beginning and evolution of Triple-Entry Accounting, is briefly presented.

The last part of the paper concerns the analysis of how TEA integrates different elements. The analysis is based on the four design principles of control, repair, internal transparency, global transparency, and flexibility. The fundamental studies on TEA are analyzed mainly in the context of internal and global transparency. Once again, (internal) accounting controls remain a key theme. At the same time, to assess global transparency, various stakeholders and systems and examined.

By assessing fundamental TEA accounting in the literature with the methodology of the four principles, we found that TEA significantly promotes transparency and system integration.

However, our analysis is focused, and rather limited, to accounting systems and controls. In addition, it is also limited on transparency and a reduction in fraud risks. Future research can assess the additional literature and features concerning TEA. For example, specific systems and SoS can be analyzed, and more perspectives, such as functionality, efficiency, and productivity, can be further examined. Another important question is how different types of Distributed Ledger Technologies (DLT) can affect TEA and SI. Moreover, innovations like AI and other emerging technologies are gaining momentum, and future research should analyze how these trends, technologies, and systems can affect integration.

2. System Integration

2.1. Definitions of System Integration

The evolution of history and technological evolution has defined, to a large extent, the field of system engineering and integration. Grady (1994) comments that one of the most used words but, at the same time, most neglected notions is integration, and 'It has so many meanings and shades of gray' (p. 3). Following from a short history, there are various engineering fields that have different perspectives and definitions of system integration (SI). Integration has been the focal point of research in several fields, like organization theory, operations management, and information systems (Mohamed et al. 2013). While Langford (2012) suggests that we 'think of integration as transforming parts into a whole' (p. 1), he also argues that system integration has been defined from various perspectives, such as enterprise applications, local applications, data, functionality, processes, organization, connections of elementary-level subcomponents to higher-level assemblies, subsystems, or systems. For the purpose of this paper, we briefly present some general definitions and then focus on Information system integration (ISI).

In a general sense, 'SI involves the efficient composition of components/subsystems into a whole that offers the required functionality and achieves specific goals (Madni and Sievers 2014, p. 37). Sanchez et al. (2020) provide a definition and, at the same time, describe the main types of system integration, 'It refers to link together system components (vertical integration), two or more systems (horizontal integration), or to provide interfaces to link physical and virtual objects of a system (end to end integration)' (p. 1017).

Conducting a literature review on information system integration, it was found that it involves two perspectives, a technical standpoint and organizational business processes (Mohamed et al. 2013). Similarly, studying information system integration, Hasselbring (2000) distinguished between different architectural layers, notably business architecture and technology architecture. The literature focusing on information systems, from traditional electronic systems to industry 4.0 technologies like blockchain, stresses the importance of information systems integration (ISI) (Rajaguru et al. 2023). Nevertheless, there

seems not to be a standard definition of ISI in the broader literature, and it is beyond the purpose of this paper to critically review this topic.

An appropriate definition for the purpose of this paper concerns accounting and broader finance in the literature. Chapman and Kihn (2009), while they recognize that ISI's scale and scope can vary, adopt the definition of 'enterprise wide packages that tightly integrate business functions into a single system with a shared database' (p. 153). This is consistent with the definitions presented above, focusing on databases but also highlighting the importance of the enterprise element. In order to capture the essence of the integrated information architecture, this is summed up as a central concept of the definition above to a single database (Chapman and Kihn 2009). Although this can be considered a limited methodological approach, we intend to adopt it for this paper since it is very relevant and can facilitate our analysis.

2.2. Integration, Accounting Control and Design Principles

Chapman (2005) argues that approaches to information systems integration (ISI) integrate data to a common database because of accounting processes, like managing record keeping and categorizing and aggregating transactions and, ultimately, resources. Chapman and Kihn (2009) further argue that information system integration enables control. The concept of control is central in the accounting literature, especially management accounting. Jack and Mundy (2013) discussed a new institutionalism in the late 1970s with organizational studies and enhanced accounting research, particularly in management control and accounting. Management accounting control (MAC) also become increasingly standardized because of accounting information systems (AIS) growing uniformity (Jack and Mundy 2013). In that sense, there is a direct relationship between MAC and AIS. Macintosh and Quattrone (2010) suggest that management accounting, in its broader sense, is about control and that the whole of society can come to a standstill if accountants and information people wrap up their systems. In that sense, it can be said that they combine AIS and control into the concept of Management Accounting and Control Systems (MACS), which is '. . .a formal mechanism for gathering and communicating data' (Macintosh and Quattrone 2010, p. 5).

There is considerable research on MAC. Ferreira and Merchant (1992) reviewed 82 studies from 1984–1992, including field research. Chalmers et al. (2019) critically reviewed 94 studies of internal control in various jurisdictions around the world, once again displaying the importance of control in accounting. They also found that IC has been influenced by information technologies (IT) and, most importantly, regulation. The enactment of regulation makes (internal) controls an essential requirement in accounting and further emphasizes its importance and necessity. Finally, in an editorial, it is supported that digitization can have substantial potential to transform accounting and control (Möller et al. 2020). Therefore, accounting and control are very relevant to system integration, and, as we intend to argue, TEA has a central role in this digital transformation.

Adler and Borys (1996) introduced four generic features for design, repair, internal transparency, global transparency, and flexibility, creating a mental model of a system and enabling users to regain control and formulate and evaluate suggestions for improvement. Chapman and Kihn (2009) expect that integrated information architecture will foster these four design characteristics, promoting and enabling an approach to control and adopt this methodology. We later discuss in more detail the methods and how they can be used in the context of our study.

2.3. Integrated Management Systems and Additional Features of Integration

We have discussed how system integration can be separated into different aspects, such as technology and applications. The other key aspects are business and organizations, and this is largely manifested in ERP. Management system integration (MSI) is a field that captures the organization's aspect. Bernardo et al. (2015) conducted a literature review and found that when organizations have multiple management systems (MMSs), the next

step is to manage them and create a single system, with benefits, such as better control and synergies, and, therefore, implement Integrated Management Systems (IMS). The literature on MSI is mainly based on Management System Standards (MSSs). MSSs are consistent with the Certification and Accreditation (C&A) presented above (Madni and Sievers 2014), and it could be never emphasized enough how important regulation and standards are for accounting and finance and, to a larger extent, for business (i.e., Sarbanes–Oxley).

While the vast majority of the literature concerns MSSs, and specifically ISO 9001 and ISO 14001 standards, beyond that, many studies propose that organizations should integrate rather than separate management systems in order to derive benefits (Bernardo et al. 2015). They critically review the literature and suggest that the integration process of management systems has the following four main aspects: integration methodology, integration strategy, integration level, and finally, the audit systems' integration. This last aspect is particularly relevant to TEA since auditing is a main function of accounting. These four aspects have some definitions and characteristics, such as, for example, internal and external audits at the integration level.

At the same time, MSI yields a range of benefits, for example, synergies and related positive outcomes. This brings us to another part of the literature, integration in Mergers and Acquisitions (M&A), which can be considered critical for organizations. Henningsson et al. (2018) reviewed the literature of over three decades from 1989 to 2016 with 70 articles, examining the role of information systems integration (ISI) in mergers and acquisitions (M&As). They presented studies on this topic and found that positive outcomes of ISI include risk management, and IT flexibility and IT standardization.

To conclude, it can be argued that there is significant research in the literature on SI. Nevertheless, it originates from various disciplines, such as system and software engineering, accounting and control, and even M&A, which can be regarded as a rather specialized area of research. In this sense, the literature is rather fragmented and covers various topics, perspectives, and factors from different disciplines. Therefore, it does not provide common practices, methodologies, and frameworks that can be widely used. However, there are intersections in certain topics, and some common aspects can be found.

3. Methods Section

The literature on system integration (SI) is rather diverse, covering many disciplines. Even within these disciplines, there is a variety of approaches and, consequently, methods. Based on the reviewed literature, it might be more useful to employ a basic model that other studies use and extend. The architecture triptych of business, technology, and application layers by Hasselbring (2000) can be considered the most appropriate since it is used by many other studies. As we have discussed, the application architecture can correspond well to TEA and facilitate our analysis.

The most important study concerning methods is that conducted by Chapman and Kihn (2009). We ground our analysis on their methodological premises for two main reasons. The first reason is that they define integration in the context of enterprise and accounting. Secondly, they provide the four design features of repair, internal transparency, global transparency, and flexibility. These design features can capture the essence of TEA, which promotes transparency and accounting control. Our analysis would also be founded and enriched on the above definitions and other integration characteristics, like the noteworthy case of laws and regulations and C&A.

This paper aims to answer two research questions. The first question explores the relationship of TEA with ISI. The second research question elaborates further and asks how TEA can facilitate ISI. We partly started to tackle the first question in the literature review. Nevertheless, in order to perform this effectively, the next part of the paper analyses the key characteristics of TEA and how they can be related to ISI. To answer the research questions, we use the four design principles (i.e., Adler and Borys 1996; Chapman and Kihn 2009). The characteristics of TEA are analyzed in the context of this four principles framework, and the relationship of TEA with ISI is assessed.

Due to the limitations of the four principles and particularly the concept of repair, we contribute methodologically by extending this framework to include functionality. Functionality is a broad term that has been extensively used in software and IT. ISO 25062 (2006) defines functionality as what the system does and what the purpose of the system is. Following an earlier definition, 'SI involves the efficient composition of components/subsystems into a whole that offers the required functionality and achieves specific goals' (Madni and Sievers 2014, p. 37). Therefore, functionality is directly related to SI. Our sample is mainly based on Thies et al. (2023) and resulted in eight studies focused on TEA, although more studies are mentioned in this context to capture additional relationships.

4. Triple-Entry Accounting

4.1. Triple-Entry Bookkeeping

Ijiri (1982, 1986) discusses how double-entry bookkeeping might not be an effective system and proposes an extension called Triple-Entry Bookkeeping. 'Double-entry bookkeeping is not an absolute system' and 'develops a framework for a triple-entry bookkeeping system' (Ijiri 1986, p. 745). Very interestingly, the author describes both Double and Triple-Entry Bookkeeping as systems. Moreover, he argues that the new system of Triple-Entry Bookkeeping can be a basis for 'fundamental concepts in management accounting, especially those in variance analysis, can be extended and integrated with those of financial accounting' (Ijiri 1986, p. 746). This is an extremely important observation for the purposes of our study. It highlights the integration of management and financial accounting with this third entry in bookkeeping. It should not be forgotten that management accounting has controls and variance, which, in essence, expresses risks that should be accordingly managed. In addition, although he considers wealth and other related concepts for creating the concept of the third entry, his main contribution is that double-entry bookkeeping might not be effective, and a third entry in the bookkeeping system can be useful.

4.2. Fraud and the Impact of the Sarbanes–Oxley Act

Before moving to TEA, we think that it is useful to make a valuable parenthesis. This is mainly related to laws, regulations, and related C&A. Accounting scandals and fraud, with the noticeable case of Enron, resulted in the Sarbanes–Oxley Act (SOX). It can be argued that SOX impacted related laws, regulations, accounting, and other standards around the world. Rockness and Rockness (2005) discuss various high-profile frauds and argue that even though SOX attempts to control reporting problems and incidents, controls in an IT environment might not, or rather, as the authors put it, will not and cannot prevent corporate fraud. This is suggested because some previous failures can be traced to IT weaknesses surrounding internal control systems as a set of invalid assumptions, challenges with design and implementation, and difficulties in internal audits (Rockness and Rockness 2005).

The literature suggests that SOA has had a significant impact on businesses, accounting, and integration. Ge and McVay (2005) found that companies disclosed at least one material weakness in their internal control after the SOX came into effect. Similarly, Patterson and Smith (2007) found that SOX has the effect of inducing stronger internal control systems and, therefore, can result in less fraud. Once again, the literature focuses on systems that can be said to be integrated with other accounting and auditing operations. Another important study found that auditors detect about three-fourths of un-remediated internal control deficiencies (ICD), which are identified under Section 404 of the SOX (Bedard and Graham 2011). We focus on internal controls because they are relevant to management accounting but also to the principle of internal (and global) transparency.

Another part of the literature studies internal control in the context of information systems. Damianides (2005) suggests that IS professionals are facing bigger challenges in providing better information due to SOX. A key study in the context of our paper analyses the impact of SOX on information technology organizations (Brown and Nasuti

2005). Brown and Nasuti (2005) firstly state that published work evaluate ERP systems that saturate the business sector and found that competencies in several core disciplines, and in particular, software integration, should be the top priority for the implementation of SOX. Moreover, in the context of SOX, they argue that ERP systems, in essence, integrate business processes and other systems, such as supply chain management (SCM), customer relation management (CRM) systems, new e-business applications as well as frameworks for the enterprise risk management—integrated framework (ERM), and ERP-centered risk management applications and solutions to manage and reduce risks, while also sharing common data. This study links SOX with integration and describes a variety of systems that are integrated alongside frameworks and applications. It also refers to sharing common data, and the concept of a common database can be implied, which is consistent with our methodology.

The impact of SOX on SI and ISI is confirmed in other studies that present a range of aspects of integration. Dittmar (2004), mainly referring to internal controls, argues that there is a need to work to integrate financial reporting and internal controls with information technology, enabling the full integration of an internal control system with financial monitoring and reporting systems. Li et al. (2012) expand and argue that SOX requirements for internal controls directly integrate and reflect the importance of information on decision making, while SOX also highlights the importance of information system controls over the financial reporting component of the firm's management information systems. This is associated with the above part of the related literature on integration, MIS, and internal controls in both accounting and information systems and assists in amalgamating these aspects. The information technology (IT) related to SOX could determine how technology systems of businesses can meet the requirements, and, in doing so, an integrated evaluation of automated IT-dependent systems and controls is needed (Chan 2004). Volonino et al. (2004) argue for a holistic approach to compliance with SOX that requires technology integration and standardization, system integration for fraud detection, integration, and the control of transactions and documentation. As we argue later, TEA can offer solutions to these challenges.

With the purpose to attain SOX compliance, business implement other C&As. Haworth and Pietron (2006) argue that enterprises can use IT controls provided by the International Standards Organization (ISO 17799) on their way toward SOX compliance and provide 124 control components of the ISO Standard and SOX implementation guidelines. Additional studies suggest ISO 9001 particularly for integration (Stimson 2011), ISO 9001 and 14001 to mitigate risks (Liebesman 2005), and combining and harmonizing Cobit, ITIL and ISO 27002/17799 (Sachedina 2008; Gehrmann 2012). This is related to the literature on MSSs and integration of management systems, and emphasizes the centrality of laws, regulations and standards.

4.3. Triple-Entry Accounting

The term Triple-Entry Accounting was first coined by Grigg (2005). Grigg (2005) described the history of single-entry and linked accounting with a firm formation, arguing that double-entry accounting arose with the modern forms of enterprise towards the end of the 15th century via Venice merchants. The digitally signed receipt, with the entire authorization for a transaction, represents a dramatic challenge to double-entry bookkeeping, at least at the conceptual level. The cryptographic invention of the digital signature gives force to the receipt and this is captured by the concept of 'triple entry bookkeeping.' (Grigg 2005).

This work is seminal because it identifies the cryptographic digital signature, but also in the context of our study, it refers to the relational database (i.e., single database concept) and software systems (IS). Moreover, it discusses how the payment system is insufficient and argues that it should be flexible and, most importantly, integrated with the needs of the users. It also suggests that it is possible to merge and, thus, integrate, the invoice with the payment itself at the receipt level. Some requirements of Triple-Entry

Accounting are also described, and among them are 'Integrated Hard Payments' and 'Integrated Application-Level Messaging'. Therefore, integration is, from the beginning, an important part of TEA.

While this highlights the cryptographic protocol, a major technological revolution came a little later. In 2008, Bitcoin was launched, and the concept of blockchain became known. Blockchain was further developed into a range of Distributed Ledger Technologies (DLTs), mainly with applications in cryptocurrencies but also in other many fields. Tasca and Tessone (2017) provide a description and taxonomy of the different types of blockchain technologies, highlighting that they affect all business sectors, allowing real-time settlements and reducing the risk of fraud.

Much of the work over the next years focused on Bitcoin. Grigg (2011) identified this innovation and inquired if Bitcoin was a Triple-Entry System. Elias (2011) quotes the work of Grigg (2005, 2011), suggesting that the Triple-Entry System can be one of the more promising uses of Bitcoin and that there would be likely some amalgamation of the aforementioned systems (i.e., Triple Entry and blockchain), indicating integration. Kiviat (2015) mentions Bitcoin, and he suggests that blockchain is a cryptographic technology for securing digital information and transactions and analyses for Triple-Entry Accounting on a transparent public ledger. 'Triple-entry accounting refers to the idea that transactions on the blockchain are essentially accounting entries that are cryptographically sealed, preventing tampering and enabling near-real-time auditing' (Kiviat 2015, p. 577). He integrates research from various fields, including some from the literature that we mentioned above, with law and regulation.

One, if not the most, important contribution to TEA is blockchain-based accounting, which provides an initial discussion on how blockchain could enable a real-time, verifiable, and, most importantly, transparent accounting ecosystem (Dai and Vasarhelyi 2017). They start their discussion on ERP systems that usually use Relational Database Management Systems (RDBMS) and how firms can integrate data, improve financial control, and increase information transparency. They suggest that blockchain can be considered an innovative type of database for the accounting module in an ERP and can be used in conjunction with the existing accounting information system. Discussing TEA, Dai and Vasarhelyi (2017) argue that by 'encoding the third accounting entry into the blockchain, a transparent, cryptographically secure, and self-verifying accounting information system could facilitate reliable data sharing' (p. 10). In addition, they present an ecosystem with blockchain-based Triple-Entry AIS in the center and share data, smart contracts with analytics, and IoT to execute accounting tasks, including stakeholders as accountants and business partners, and they mention that many of these elements could be integrated. Their work is consistent with the definitions, indicating a single database and aspects such as ERP and transparency, and it can be argued that this constitutes the first detailed model of TEA.

Faccia and Mosteanu (2019), examining previous work (for example, Dai and Vasarhelyi 2017), argue that the transparency and presentation of accounts are mandatory for any business, and despite current practice and all legislative rigors, there is still room for errors and financial fraud. They propose triple-entry blockchain accounting for enduring business, with benefits including reducing the risk of error, lowering the risk of fraud, system automation, cost savings, as well as increased reliability in financial reports and workflow. Tan and Low (2019) view blockchain as the database engine in the accounting system and suggest that transactions recorded in a blockchain can be aggregated (or, in this context, integrated) into financial statements, reducing errors and discouraging fraud. There has been an expansion of the literature on TEA in recent years. Thies et al. (2023) conducted a systematic review of the literature on TEA, and after a broader initial search, they ended up with a sample of 26 studies, with only 8 of those focused on TEA. In the following analysis, we also focus on these eight fundamental TEA studies, but we try to also expand on the rest of the studies to provide a more inclusive and comprehensive examination of TEA integration.

5. Analysis

5.1. Repair and Functionality

'Repair refers to the break down of control processes, providing capabilities for fixing them. . . An enabling system would be designed such that it might be refigured by users, acting as a valuable resource informing their actions. The intuition is that not everything can be foreseen in advance, and some intellectual work (and consequent freedom) must be left to users to determine the appropriate course of action in such unforeseen circumstances.' (Chapman and Kihn 2009, p. 152). Repair is a rather challenging term to deal with. Accounting and auditing controls and processes can be broken down, fixed, and improved.

The importance of controls was discussed earlier in the section on system integration. Management accounting systems are rather built on the enterprise-wide system and implemented by consultants, and it can be argued that people are skillful in repairing the shortcomings of these systems (Granlund 2011). Control processes can be disrupted by technological innovations and data changes, and therefore, control processes might not be effective and should be repaired. Moreover, accounting standards and regulations, as well as certification and accreditation (C&A), can also change and result in the need for the repair of accounting controls. On the IT side, there can also be technical issues that can break down control processes.

Blockchain has proven so far to be a strong cryptographic technology and enables the secure communication of information. While blockchain can be considered not to require repair, the accounting controls and other features of the integrated system are likely to require repair by the user of the system. This has significant implications for accounting, auditors, and managers who are not replaced, but their role is expanded to implement these controls in TEA. TEA is, therefore, subject to repair since it integrates different layers (Hasselbring 2000), including the business architecture layer and the application layer, which are subject to changes and repair, and the technology layer, which is characterized by blockchain and remains rather robust. This is also consistent with the literature on integration and demonstrates how accounting controls play an important role. There is an inseparable bond between (internal accounting) controls and TEA. 'This leads to the second design characteristic of enabling control systems, internal transparency. (Chapman and Kihn 2009, p. 155).

Another term that might fit better and capture the features of repair is functionality. In simple terms, functionality is about a system functioning properly. A system should also function effectively according to the requirements when it is integrated with other components or systems. It can be, therefore, argued that functionality can encompass the control processes of repair since it also provides the ability to fix and change controls. Although a rather general term, functionality has been extensively used in the context of software. However, it has been less used in systems and systems integration, and our analysis contributes to expanding the scope of functionality. As discussed in the methods section, functionality refers to what a system does in order to achieve specific goals. Moreover, functionality can incorporate the stakeholder approach (Madni and Sievers 2014). Therefore, it is consistent with the principle of repair that is refigured by users.

Functionality, in the case of TEA, focuses on controls that can enhance risk management and fraud prevention. It is not only that a system should function as it is expected according to requirements and stakeholder specifications, but this functionality should also be effective. Blockchain technology and TEA can facilitate the secure functioning of controls. Hasselbring (2000), discussing enterprise system integration, argues that architecture should align with application functionality and also a new functionality must be integrated with existing applications, data, and, in general, systems. The suggestion of new functionality is analogous to the reconfiguration of the system by the user in the repair principle. TEA and DLTs can offer new functionality. A notable example is smart contracts offered by different types of DLT (Ethereum, Cardano, etc.) and other blockchain applications. TEA can feature these DLT applications and enhance new functionality and innovation in accounting and business applications.

Dai and Vasarhelyi (2017) argue that blockchain's functionality has evolved in many domains and suggest that blockchain's function of sharing information, protecting data integrity, and programmable and automatic control of processes, could help in the development of a new accounting ecosystem. (Cai 2021), examining the Pacio Solution, the blockchain ecosystem with triple-entry accounting, discusses different types of blockchain technologies. They identify that a problem is a closed ecosystem, which is not decentralized and publicly accessible, limiting functionality and utility, while there are innovative blockchain projects that can offer new functionality. Pascual Pedreño et al. (2021) highlight the cryptographic function of blockchain as well as the accountant (user's) advisory function to the development and application of blockchain solutions. Similarly, Desplebin et al. (2021) argued that accountant and auditor functions are set to change, the connectivity function among stakeholders is going to grow, and in general, blockchain could facilitate data management with new functionality for accounting.

Kitsantas and Chytis (2022) reaffirm that blockchain enables cryptographic hash functions and suggest that, in TEA, a BaaE platform incorporates a plethora of innovative functionalities, and most importantly, this functionality involves three dimensions of integration, including vertical upstream integration, vertical downstream integration at the level of distribution channels and customers, and horizontal integration. Finally, Secinaro et al. (2021) summarize the business functions of several authors from the combination of blockchain with auditing and control systems. In that sense, functionality is a useful term that can better capture not only the technical but business aspects of TEA. It has also been displayed that functionality facilitates system integration in TEA.

5.2. Internal Transparency

Internal transparency occurs 'When equipment is designed to reduce reliance on users' skills, there is little reason to provide users with any visibility into its internal workings.' (Adler and Borys 1996, p. 72).' Internal transparency is about understanding of the working of local processes' and promises a notion of control (Chapman and Kihn 2009, p. 152). Internal transparency can be considered one of the most important principles in the context of Triple-Entry Accounting and ISI. In the above discussion, we highlighted the importance of internal controls, especially after the introduction of SOX (Ge and McVay 2005; Patterson and Smith 2007, etc.). Internal controls are directly related to internal transparency because they imply the processing and disclosure of information. Moreover, these local processes can specifically refer to accounting processes in this context and, therefore, validate the analysis.

Dai and Vasarhelyi (2017) provide a discussion on how blockchain could form a transparent accounting ecosystem, focusing on accounting processes. They argue and propose a blockchain-based accounting ecosystem in which accountants and managers (as well as investors and business partners discussed later) could collaborate to verify transactions, and these components could come together, therefore integrated, and 'comprise a real-time, verifiable, and transparent accounting ecosystem' (p. 5) and 'Smart contracts could serve as automatic controls that monitor accounting processes' (Dai and Vasarhelyi 2017, p. 9) facilitating internal transparency. They found that the third accounting entry of blockchain is transparent and cryptographically secure, and an accounting information system can be generated that offers continuous reporting. This accounting information system integrates many stakeholders and the accounting processes they are involved with.

(Carlin 2019), examining blockchain and accounting beyond a double entry, found a strong consensus that blockchain technology applications in the context of accounting processes as a range of record-keeping and transaction-processing qualities that could improve transparency. Similarly, Karajovic et al. (2019) suggest that blockchain's main asset is transparency and being able to see entries when they occur, ensuring transparency for everyone involved. Nevertheless, much of the discussion is general and expands to additional stakeholders and processes that are examined later.

While Faccia and Mosteanu (2019) highlight transparency as a key property in the abstract and mention various accounting processes, such as procurement and budgeting, they rather use errors and fraud to capture this notion. They argue that despite the auditing controls, commercial frauds have unfortunately always occurred in double-entry accounting, and the traditional model offers too much centralized power to the issuer and potential for internal fraud, while triple-entry accounting through blockchain brings many advantages, such as reducing the issuer's ability to commit fraud and reduce such risks.

Secinaro et al. (2021) conducted a literature review and found that the main features of blockchain are transparency consensus, cryptographic hashing, decentralization, and verifiability. Concerning the blockchain characteristics, they found that 'Decentralization provides companies with a continuous flow of information, auditors with accurate analysis and legislators, if necessary, with fraud control in accounting and budgeting. Therefore, it increases the level of transparency and trust among stakeholders.' (Secinaro et al. 2021, p. 194). This is consistent with the above arguments about blockchain TEA reducing the risk of fraud in accounting and budgeting processes.

But most importantly, the above quote displays how the features of blockchain are interrelated. Excepting the relationship between transparency and decentralization, transparency has a strong relationship with verifiability. The 'Verifiability of data and transparency are closely related' and are also related and recalled by decentralization and consent (Secinaro et al. 2021), displaying even more complex interrelations among the blockchain characteristics. Blockchain combines transparency and verifiability in validating the authenticity of information and preventing the manipulation of data and fraud; transparency is similar to the truthfulness of the information, and transparency with verifiability can increase productivity and result in greater economic sustainability for accounting and financial reporting (Secinaro et al. 2021). They also referred to transparency along with trust issues.

Pascual Pedreño et al. (2021) suggest that blockchain and Triple-Entry Bookkeeping offer complete transparency and eliminate the need for the trust of any intermediaries, for example, the trust of bookkeepers and auditors who can be susceptible to corrupt behavior. Once again, this is consistent with the above arguments concerning fraud. It is useful at this point to also recall the introduction and impact of SOX, which are intended to reduce fraud and increase trust in companies and markets. Nevertheless, different types of DLTs, notably centralized and decentralized, can have different impacts on intermediaries and, thus, trust and transparency. Blockchain in accounting promoted transparency, which consequently led to trust in the authenticity of records, accounting information, and processes and the fight against fraud and corruption (Pascual Pedreño et al. 2021). They conclude that the Triple-Entry bookkeeping system has several advantages, and the most distinct are transparency, trust, ease of auditing, and reconciliation; such a system allows accountants to reconcile the account balance, transaction, and reporting process, denoting the integration of these accounting processes through internal transparency.

Desplebin et al. (2021) stated that blockchain is characterized by three principles of transparency along with the decentralization and protection of data (i.e., verification, authentication, etc.), which, as discussed, can be interrelated with transparency. They focused on the transparency of sensitive financial data, and related them to tax services, and highlighted dubious tax practices. Very importantly, they highlight the issue of the extent of the blockchain's transparency. They also discuss which type of blockchain can be used (i.e., public, private). The use of different types and data in the blockchain is an important question that can enhance or limit transparency and integration among accounting processes and systems within the organization.

Kitsantas and Chytis (2022) review similar studies on transparency in TEA accounting and adopt the definition of blockchain as a linear shared database, enabling digital transparency in information records and eliminating third parties. Moreover, they connect accounting standards, notably the Generally Accepted Accounting Principles (GAAP) criteria, with smart contracts and argue that TEA, with the innovative architecture of

a blockchain as an ecosystem (BaaE) platform, make firms' records and balance sheets, income and cash flow statements visible to all concerned parties (internal as well as external) improving the accuracy and the transparency of the information. The BaaE could be integrated with TEA and improve transparency as well as have other advantages.

5.3. Global Transparency

While 'Internal transparency refers to internal functioning of the equipment or procedure as used by employees; global transparency refers to the intelligibility for employees of the broader system within which they are working' (Adler and Borys 1996, pp. 72–73), 'Global transparency refers to the understanding of where and how the local processes fit into the organisation as a whole' (Chapman and Kihn 2009, p. 152). We expand this concept of global transparency to encompass participants beyond the accounting processes and the specific organization, including regulators, other business partners and stakeholders (i.e., NGOs, etc.). This more extensive definition of global transparency is beneficial since many enterprises can be Multinational Corporations (MNCs) with a global reach. They can be subject to multiple regulators and stakeholders and have a plethora of supplies all over the world. TEA can assist in providing security and transparency of transactions. Already there are plenty of blockchain applications in supply chains (Chang and Chen 2020) that should be accompanied by payments and, therefore, accounting transactions that can be facilitated by TEA.

Continuing from Kitsantas and Chytis (2022), the Blockchain as an ecosystem comprises a distributed and decentralized system that can reflect this broader conceptualization of global transparency. 'In particular, the above architecture of BaaE could have the potential to change the integration horizontally and vertically, which are essential to automate data exchanges among business entities to collaborate with suppliers, customers, and manufacturing systems. ... Integrating the next digital generation of Industry 4.0, such as Cloud Computing, Artificial Intelligence (AI), Machine Learning (ML), Predictive Analytics (PA), and the Internet of Things (IoT) with the BaaE platform. . .and decentralized information system such as Triple-Entry Accounting (TEA)...providing a holistic setup for the next-digital generation of a decentralized ecosystem platform.' (Kitsantas and Chytis 2022, pp. 1150, 1148). As argued in the above part this can increase internal transparency in accounting processes but most importantly global transparency includes supplies and customers. It should be also noted that global transparency is facilitated by the integration of various technologies and systems.

Pascual Pedreño et al. (2021) indicate that Triple-Entry bookkeeping and the development and adoption of blockchain accounting and practices can result in global transparency as well as new possibilities for compliance, at both the national and international levels, emphasizing its importance for regulators. Triple-entry account systems can comply automatically with accounting standards and regulations and could even automate tax filings (Faccia and Mosteanu 2019). Similarly, Karajovic et al. (2019) suggest that blockchain can automate taxation and there can be more transparency since regulators are able to expose tax fraud. (Cai 2021) mentions standards and in particular, the International Financial Reporting Standard (IFRS) aiming for transparency and trust, arguing that a new accounting recording method, in the form of Triple-Entry Accounting, can address fundamental issues of transparency and trust between insiders (internal transparency) and outsiders (global transparency).

Secinaro et al. (2021) present other applications of global transparency like the provision of data to banking, investors, and multiple stakeholders, auditing, and even corporate voting. Dai and Vasarhelyi (2017) is not only one of the most important and early studies but at the same time, it argues for an ecosystem, comprising accountants, managers, as well as investors and business partners. While the first two stakeholders can be considered part of internal transparency, investors and business partners are rather part of global transparency. They suggest that, with ERP systems, firms can integrate data from different business segments and processes, improve financial control, and therefore, increase transparency

while blockchain and TEA are considered a new type of database that can be used in an ERP or with the existing accounting information system. (Dai and Vasarhelyi 2017). Faccia and Petratos (2021) examine ERP and AIS and suggest that there are blockchain applications in accounting (notably e-procurement) as well as other business areas like supply chains that increase transparency, and in this context, global transparency, facilitating integration.

5.4. Flexibility

'Flexibility attends to the organisational members' discretion over the use of control processes (i.e., to the extent that they can turn them off). . . Enabling systems seek to facilitate flexible responses to emerging events to the extent that the control systems can be turned off, when not needed. While unconstrained flexibility is unlikely to be beneficial, ISI offers an effective framework for the mapping out of individuals' areas of responsibility and control. . . As such, ISI offers users flexible (but constrained) options.' (Chapman and Kihn 2009, pp. 152, 156). Flexibility can be considered complementary to repair. It can be argued that in repair control processes that break down while in flexibility they are rather adapted to the circumstances.

The main issue with flexibility is how much discretion is allowed for the members of the organization to alter the control process. TEA puts significant limitations on the level of discretion. Many of the accounting processes, and most importantly the recording of the transactions, are automated and cannot be modified. Nevertheless, it should be noted that there are two crucial issues. The first issue is the governance and consensus mechanism of the blockchain for managing the accounting processes and controls, which consequently depends on both the business and the technological layers. The second challenge stems from the first and concerns about which DLT can be used for TEA and remains an issue for future research.

6. Conclusions

In this paper, we attempt to examine the relationship between TEA and SI and the research question of how TEA promotes integration. We focused on the fundamental TEA literature and assessed it with the method of four design principles, emphasizing transparency, both internally and globally. We found that TEA significantly improves internal and global transparency as well as repair and flexibility. Therefore, TEA promotes system integration. TEA can integrate multiple stakeholders, such as managers, accountants, tax authorities, regulators, and partners. It can also integrate technologies like Cloud Computing and Artificial Intelligence (AI), and thus, it can constitute a foundational technology of Industry 4.0. TEA can integrate ERP and other systems, notably supply chain through blockchain applications, and further facilitate Industry 4.0 integration.

This analysis suggests that TEA can be considered an integration of accounting controls itself, corresponding to the business architecture layer and blockchain that corresponds to the technology layer. While transparency is rather directly affected by TEA, repair and flexibility can be more influenced by the business layer and consequently by stakeholders. Governance and a consensus mechanism are, hence, essential to restrain the discretion of managers and accountants in changing accounting control processes. Nevertheless, TEA creates transparent and verifiable accounting transactions, which cannot be modified and are, in principle, automated.

Limitations and Future Research

The main limitation of this paper is that our analysis is focused on accounting systems and controls. We assessed a limited number of studies that are considered fundamental in TEA. Future research can expand on other studies associated with TEA. Moreover, our methods are limited to the four principles of control and system integration and future research should use alternative methodologies. Transparency was the main perspective. While transparency is a central perspective, future research can expand to other important aspects, such as value creation, productivity, efficiency, and sustainability. Moreover, the

scope of this analysis can be extended, especially concerning global transparency, and other global features of integration. We tried to provide an initial quantitative analysis combining a matrix with the two main methodologies (Appendix A). Nevertheless, future research can use quantitative methods to further investigate this area.

Following from these conclusions, consensus mechanisms on blockchain should be examined and their effect assessed, particularly regarding flexibility and repair. In particular, we considered flexibility to be rather limited and, therefore, the studies analyzed did not consider it as a feature of TEA and SI. Future research can examine in more detail TEA accounting and auditing operations and assess flexibility. This leads us to a more fundamental issue for future research, which is to examine how the different types of Distributed Ledger Technologies (DLT) can affect TEA, system integration and transparency. Finally, the relationship of TEA with emerging technologies, such as AI, and cloud computing and how they can be integrated, as well as the broader question of integration with Industry 4.0 are worthwhile endeavors.

Funding: This research received no external funding.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Acknowledgments: The author would like to thank Alessio Faccia for his comments.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Matrix combining the methodologies of Thies et al. (2023) and Chapman and Kihn (2009).

	Internal Transparency	Global Transparency	Repair and Functionality	Flexibility
Cai (2021)				
Carlin (2019)				
Dai and Vasarhelyi (2017)	✔	✔	✔	
Desplebin et al. (2021)	✔		✔	
Faccia and Mosteanu (2019)	✔	✔		
Kitsantas and Chytis (2022)	✔	✔	✔	
Pascual Pedreño et al. (2021)	✔	✔	✔	
Secinaro et al. (2021)	✔	✔	✔	

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