# The Use of Blockchains to Enhance Sustainability Reporting and Assurance*

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## ABSTRACT

The changing dynamics of the accounting profession have been strongly influenced by emerging technologies and the demand for nontraditional metrics and information by stakeholders and regulators. In this article, we perform an exploratory content analysis to examine the role that blockchain technology can play in enhancing sustainability reporting and assurance. The benefits to companies and assurance professionals in using the distributed ledger technology of blockchain are increased trust, transparency, and traceability, which matches stakeholders' demands as it relates to sustainability reporting. This article identifies and analyzes potential and current use cases of blockchain in the United States and Canada to assist accountants and auditors in preparing and reviewing sustainability information. We highlight how augmenting traditional reporting systems with blockchain can overcome problems with sustainability reporting. We discuss implications for practice in detail—finding that blockchain is well-positioned to provide reliable tracking and custodial support as it relates to sustainability information currently being self-reported by many firms, such as greenhouse gas emissions, conflict mineral disclosure, or product provenance, among others. Expanded adoption of blockchains by companies will lead to higher-quality information being included in sustainability reports and allow assurance professionals to verify a wider range of information, potentially leading to uniform standards in the evaluation of sustainability reports.

**Keywords** Blockchain; Distributed ledger; Sustainability reporting; Sustainability assurance

## L'UTILISATION DE LA CHAÎNE DE BLOCS POUR AMÉLIORER L'INFORMATION ET L'ASSURANCE EN MATIÈRE DE DURABILITÉ

## RÉSUMÉ

La dynamique évolutive de la profession comptable est fortement influencée par les technologies émergentes et la demande de mesures et informations non conventionnelles de la part des parties prenantes et des organismes de réglementation. Dans cet article, nous effectuons une analyse de contenu exploratoire afin d'examiner le rôle que la technologie de la chaîne de blocs peut jouer pour améliorer l'information et l'assurance en matière de

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durabilité. Pour les entreprises et les professionnels de l'assurance, les avantages liés à l'utilisation de la technologie du registre distribué de la chaîne de blocs sont une confiance, une transparence et une traçabilité accrues, ce qui correspond aux demandes des parties prenantes concernant l'information relative à la durabilité. Dans la présente étude, nous cernons et analysons des cas d'utilisation de la chaîne de blocs éventuels et actuels aux États-Unis et au Canada pour aider les comptables et les auditeurs à préparer et à passer en revue l'information sur la durabilité. Nous montrons de quelle façon l'ajout de la chaîne de blocs aux systèmes de communication d'information conventionnels peut résoudre des problèmes associés à la production de rapports financiers sur la durabilité. Nous discutons en détail des conséquences de cette technologie sur la pratique comptable, en établissant que la chaîne de blocs est en bonne position pour fournir un suivi fiable et une certaine forme de surveillance concernant l'information sur la durabilité actuellement communiquée par de nombreuses entreprises, comme les émissions de gaz à effet de serre, les déclarations sur le minerai de conflit ou la provenance des produits. L'adoption à plus grande échelle de la chaîne de blocs par les entreprises permettra d'intégrer de l'information de meilleure qualité aux rapports sur la durabilité et donnera aux professionnels de l'assurance l'occasion de vérifier davantage de renseignements, ce qui pourrait entraîner l'établissement de normes uniformes pour l'évaluation de l'information sur la durabilité.

**Mots clés :** chaîne de blocs; registre distribué; information sur la durabilité; assurance de la durabilité

Blockchain technology was introduced as the foundation of Bitcoin and other cryptocurrencies. Since its introduction as a platform for mining and transacting in cryptocurrencies, it has expanded into the financial services, supply chain and logistics, stock registration, and auditing and assurance industries. While there is not yet an established standard definition of blockchain, most definitions recognize that "blockchain is a digital ledger created to capture transactions conducted among various parties in the network" (CPA Canada, AICPA, and UWCISA, 2017) and that the ledger is distributed, decentralized, and—if designed effectively—immutable (Dai and Vasarhelyi, 2017; Sheldon, 2019; Stein Smith and Castonguay, 2020). The decentralized and distributed nature of the technology creates a mechanism for users on the blockchain, called nodes, to be able to maintain control of the information posted without relying on the other individual members involved. Unlike a traditional database, each verified transaction, or block, is posted following an authentication process agreed upon by the existing nodes, and the record of the transaction is then distributed to all nodes. The distribution of the blocks to relevant nodes diminishes data integrity risks because a real-time original record is maintained by each node and not a centralized entity.[1] If one or more nodes become compromised or hacked, or if there are attempts to alter the block, the blockchain

1. Despite preapproved authentication procedures (e.g., majority, full consensus, value-weighted, etc.), the quality of the blocks is limited to the quality of information authenticated. If nodes fail to exercise diligence in authentication, the information stored on the blockchain is no more or less valuable than other forms of information. In fact, it can make it difficult to correct or edit improperly authenticated blocks. We thank an anonymous reviewer for highlighting this caveat.

will not recognize the compromised transaction because it does not match the block maintained by the uncompromised node. Therefore, the more nodes involved in the distribution, the more secure the blockchain becomes.

Due to its immutability and decentralization, blockchain is most beneficial when different incentive structures exist across parties to a transaction and those parties need to trace information through time and numerous intermediaries. Thirty-two percent of companies considering the adoption of blockchain are planning to do so, with the ability to track and trace as the primary reason for adoption (Deloitte, 2019: 32), a capability made possible by integrating blockchain with existing technologies such as the Internet of Things (IoT) and radio-frequency identification (RFID) tags (Sheldon, 2020).[2] In this article, we focus on a growing area of corporate reporting that demands trust, transparency, and traceability: sustainability reporting.

A 2017 KPMG survey found that 93 percent of the world's 250 largest companies participate in corporate responsibility reporting capturing environmental, social, and/or governance issues related to sustainability (KPMG, 2017). Despite the high level of participation, there are concerns about the lack of transparency and misreporting in these reports. The IASB Chair stated in a speech on sustainability reporting that "greenwashing is rampant" (Hoogervorst, 2019: 5) and there is concern that systems and data collection processes are not as developed as those for historical financial information (GRI, 2013). Augmenting traditional financial reporting technology and systems with blockchain can begin to address some of these issues. Furthermore, blockchain can enhance sustainability reporting and assurance and "facilitate a system shift from shareholder to stakeholder value, and to expand traditional financial capital accounting to also capture social and environmental capital" (PwC, 2018: 7).

Within the supply chain industry, blockchain has been considered an emerging technology capable of tracking products from their origins as basic raw materials to final customer delivery, mitigating the risk of counterfeit or illegal goods and products (Apte and Petrovsky, 2016). There is much research in operations management and supply chain management that discusses how the integration of blockchain can enhance supply chain effectiveness. Prior research finds consumers have an increased appetite to understand and track the origins of the products they consume, such as food and pharmaceutical products (Francisco and Swanson, 2018; Kshetri, 2018; Rogerson and Parry, 2020). Similarly, CPA Canada (2019) posited that blockchain technology could allow for an open-sourced list of companies that have achieved sustainable practices. In practice, the popular press has highlighted this—retail giant Wal-Mart has tested blockchain applications that enable them to track produce and other perishable groceries from planting through the entire supply chain to the final customer touchpoint as a way to be able to trace and isolate potential contamination, such as salmonella (Kharif, 2016). Additionally, Kouhizadeh and Sarkis (2018) describe how blockchain can aid in sustainability efforts, such as energy, waste management, materials management, purchasing, supplier

2. See CPA Canada et al. (2017) for a summary of the impact of blockchain technology on accounting and auditing.

development, and vendor selection. Expanding upon Kouhizadeh and Sarkis (2018), Wang, Beynon-Davis, and Han (2019) summarize the literature surrounding the use of blockchain in supply chains, finding that the use of blockchain can increase security and transparency of the supply chain, as well as further integrate digitalization.

The benefits of blockchain used in a supply chain setting have a logical extension to the audit and verification of the information stored on the blockchain to comply with sustainability reporting requirements, such as reporting on the use of conflict minerals and greenhouse gas emissions. Tracing a product through its manufacturing and distribution process to ensure adherence to standards and verifiability is simplified on a blockchain. Since all of the data for a given product or mix of products would be updated by the parties involved at the given stage (i.e., miners, transportation companies, producers, wholesalers, and sellers), this would provide multiple verification points and opportunities for auditors to assess the reliability of the information from each party involved. Writing with researchers and practitioners reviewing implementation guidance in mind, we perform an exploratory content analysis by combining academic research, practitioner articles and reports, and case studies to identify and discuss shortcomings in sustainability that are improved by the use of blockchain. We analyze existing blockchain usage and describe how accountants and external assurance professionals can implement a blockchain solution to enhance sustainability reporting and assurance services and assess the strengths and weaknesses of utilizing blockchain in these areas. Where applicable, we expand existing research to provide recommendations to improve the effectiveness and functionality of blockchain in sustainability reporting. This article is not intended as a technical evaluation and implementation guide for blockchains in the sustainability reporting environment. We leave the technical aspects to future researchers.

Regulators, auditors, and accountants should be aware of the impact blockchain technology could have on this important and growing segment of the accounting market. This article seeks to inform these parties and contributes to the evolving stream of academic literature addressing blockchain's usage in sustainability reporting. We expand on previous work to integrate governance best practices, incorporate the use of other accounting technologies in sustainability reporting, and develop a deeper understanding of blockchain's potential in the space. As sustainability reporting and assurance expands and its accompanying standards and requirements further develop, it is crucial to simultaneously add to the conversation the consideration of how technology could enhance or assist in streamlining this reporting process. Our research addresses how traditional information systems and enterprise resource planning (ERP) systems can be enhanced through blockchain integration, recognizing that full replacement would not be an efficient solution for many companies reporting on sustainability.

## BLOCKCHAIN

### Fundamentals and Adoption

For this research, we will focus on the simplified definition of blockchain: an immutable, distributed, and decentralized digital ledger designed to record and transmit information

across parties (CPA Canada et al., 2017; Dai and Vasarhelyi, 2017; Sheldon, 2019; Stein Smith and Castonguay, 2020). Under the simplified definition, blockchains can be either public or private.[3] Public (also referred to as permissionless) blockchains are available to anyone with computer access and the computing power to participate on the blockchain. These public blockchains are represented by much of the cryptocurrency blockchains that exist, such as Bitcoin and Ethereum. On public blockchains, each party can observe and access the same ledger as the other members to the blockchain in a state of near full transparency across participants. This feature surrounding full transparency and decentralization that made the design so appealing to the founders of Bitcoin is the precise feature that has led to the limited adoption of public blockchains by private companies and governments. Most private entities would prefer that their transactions are only visible and accessible on a confidential or need-to-know basis.

In contrast to public blockchains, there exist more centralized and secure private (also referred to as permissioned) blockchains. These blockchains limit access to view, transmit, possess, and verify transactions and information to authorized users only. Users must be given access or agree to share access before being able to join private blockchains. The majority of businesses currently use private blockchains established by an individual entity or group of entities through a consortium blockchain (CPA Canada et al., 2017; Deloitte, 2019). In private blockchains, entities can elect to establish the rules of the blockchain's operation based on what best suits the needs of the parties to the blockchain without having to consider unauthorized users gaining access to the data that is transmitted across the private blockchain. Essentially, entities that employ private blockchains are trading the decentralization feature of public blockchains for more access control. For example, a retailer looking to utilize a private blockchain for its supply chain can authorize its suppliers and shipping companies to access and participate on the blockchain, while denying access to competitors and customers. The information is still distributed to the various parties on the ledger, but which parties are privy to that distribution is maintained by a central entity or entities.

Once access rights are established, the parties to private blockchains must determine how consensus and authentication are determined, what rights additional authorized users are given, how authorized users may be added to the blockchain, and the amount and quality of the information that is to be stored or transmitted on the distributed ledger. Together, these considerations form the blockchain's governance (Stein Smith and Castonguay, 2020). Like traditional internal controls or a corporation's tone at the top, the stronger the governance, the more reliable the information. Stein Smith and Castonguay (2020) identify three critical governance practices that must exist for private blockchain to be a more reliable reporting platform than existing information technology infrastructure:

1. To ensure only necessary and authorized users have access to the blockchain information, rigorous customer and business partner acceptance practices must be

3. Some researchers have drawn distinctions between public and private blockchains and further drawn a distinction between permission structures within private blockchains (Dai and Vasarhelyi, 2017). In our research, we use "private" and "permissioned" interchangeably.

in place *before* operating the blockchain. A lack of clear practices in place before implementation would indicate poorer governance and an inability to properly manage the technology.

2. To improve confidence over the quality of data posted to the blockchain and the data's likelihood to remain confidential, an analysis of the data integrity policies and history of breaches of the other parties on the blockchain must be performed. This matters more in a blockchain environment where the information on the blockchain is distributed to all members and not maintained by a single entity (i.e., decentralized).
3. To verify that intentional and unintentional data vulnerabilities are addressed in an expedited manner, the communication apparatus between parties on the blockchain must be consistent and timely. Companies must be willing and able to identify and notify the other parties when a potential vulnerability arises, and policies must exist to settle disputes between conflicting parties on the blockchain.

In addition to the aforementioned policies and procedures that must be operationalized for blockchain to be effective in sustainability reporting, there must be buy-in by those charged with governance and policy setting: the board of directors, the audit committee to the board of directors, and senior management (Stein Smith and Castonguay, 2020). Without the support of senior leadership and governing members, private blockchain solutions to sustainability are unlikely to be successful. Furthermore, governance considerations and involvement by the board cannot be limited to the initial implementation or launch. The involvement must be comprehensive and ongoing (Stein Smith and Castonguay, 2020).

Such private blockchains with initial strong governance are represented by the previously discussed Wal-Mart produce blockchain beta product and the state of Delaware's consideration for blockchain in the securities market.[4] Delaware has authorized the use of blockchain by corporations domiciled in the state to issue and track shares of stock, reducing trade settlement times and costs associated with the buying and selling of stock—essentially removing the broker as an intermediary and providing real-time access to the number of shares outstanding and their direct owners (Markell, 2017). These examples only begin to highlight the potential of private blockchains for business users. Eighty-six percent of respondents in Deloitte's (2019) blockchain survey stated that they believed "blockchain will enable new business functionalities and revenue streams" in their industry (Deloitte, 2019: 23). Companies are expanding their visions for blockchain to move past payments and digital currency activity. Within the group of business leaders considering adopting blockchain, 43 percent are considering adoption with a primary goal of improving data validation, and another 32 percent are considering adoption for the ability to track and trace (Deloitte, 2019: 32). The ability to track and trace is expanding from its foundation in digital assets such as cryptocurrencies to tangible assets that

4. We recognize that state and municipality governance differs from that of corporations, but the underlying approach and necessary support from leadership remains consistent between public and private entities.

exist in the physical world (e.g., tangible inventory). While as of this writing there is no directly connected method to track physical assets on the digital blockchain, Sheldon (2020) finds that the IoT (e.g., connected devices), RFID tracking, and real-time camera feeds accessible via blockchain can reduce the risk that the true state of the physical asset does not match its blockchain status. By connecting multiple devices and tracking mechanisms, coupled with third-party shipping and logistics involvement, companies can effectively use blockchain to track and maintain physical assets that exist off of the blockchain (Sheldon, 2020).

Across the various uses for blockchain, executives are recognizing they have the potential to utilize blockchain to improve the quality of information used to generate external reports through blockchain's smart contracts, validation and consensus algorithms, and third-party verifications. It is likely they will only continue to find new ways to incorporate the technology.

Because private blockchains are preferred by the overwhelming majority of private business enterprises and governmental entities, we focus on this type for our research. Until public blockchains garner more widespread business adoption, blockchains should continue to be understood in the private and permissioned setting for accountants, auditors, and assurance providers. We discuss this understanding in the next section.

## Blockchain Application in Audit and Assurance

Blockchain implications for audit and assurance services are still in the introductory stage, with researchers and practitioners beginning to formulate how blockchains will impact the industry—recognizing that opportunities abound. As noted by Dai and Vasarhelyi (2017: 6), blockchain has the potential to "serve as a foundation to enable automatic assurance." As this potential to transform the audit industry has become better understood, much of the audit literature has focused on how blockchains should be assessed by auditors performing an audit of internal controls over financial reporting (Sheldon, 2019), auditors considering corporate governance strengths and weaknesses (Schmitz and Leoni, 2019; Stein Smith and Castonguay, 2020; Yermack, 2017), and auditors auditing financial statements of public companies (CPA Canada et al., 2017). In addition, Rozario and Thomas (2019) consider how blockchain technologies can improve "the expectation gap between the auditors, financial statement users, and regulatory bodies" by the utilization of smart contracts and smart audit procedures. Instantaneous, distributed, and immutable information could improve the ability of public accounting firms to undertake continuous auditing and audit near full populations of transactions or account balances by serving as a node on the blockchain and obtaining high-quality evidence provided by multiple external parties (CPA Canada et al., 2017). Within the blockchain apparatus, smart contract functionality and the speed at which transactions are automatically processed reduce the likelihood that human error or a fraudulent transaction will make its way into the financial reporting system if all parties are acting independently.

Ideally, blockchain possesses the potential for real-time financial reporting and validation by auditors, both internal and external. Campbell Harvey of Duke University described the potential for blockchain to improve financial reporting in the following way: "We currently use this model that relies on reporting numbers from the past within annual, semiannual, and quarterly reporting" (FERF, 2018). Harvey further explains, "What blockchain allows you to do is create a ledger maintained by the internal audit team that receives immediate and secure data from the business lines, which can then be potentially validated by external auditors in real time" (FERF, 2018). This is the promise of continuous auditing applied. As the volume of transactions and the percentage of a company's overall operations move onto the blockchain, the opportunity and benefit for auditors to observe the validation of transactions in real time increases. The need for large-scale sampling on a quarterly or annual basis would be greatly reduced or even deemed redundant.

In addition to real-time reporting, the need for auditors and other assurance providers to repeat their evidence-gathering activities across multiple companies using multiple reporting systems could be reduced as different companies join similar private blockchains (FERF, 2018). Because the ledger is distributed and maintained by each party to the blockchain, the auditor could potentially audit the information in one location, similar to service organization control reports. Both the assurance provider and the company would benefit. The assurance provider would obtain high-quality evidence and the corporations on the blockchain would be compensated through lower audit fees.

Even if assurance professionals can apply continuous real-time assurance directly on the blockchain, reducing manual audit work, the need to have such assurance professionals will not be eliminated. Full blockchain implementation and integration will shift much of the focus away from more routine evidence-gathering activities (i.e., three-way matching, confirmations, etc.) and into a deeper analysis of risk analysis and judgments made by management and other report preparers. There will still be a need for assurance professionals to apply their experience and professional skepticism to assess complex management estimates, nonroutine transactions on or off the blockchain, internal controls, and the underlying assumptions embedded in the blockchain smart contracts and underlying code (CPA Canada et al., 2017; FERF, 2018). However, the manner in which they apply their skills, education, and experience will differ from their present application as the technology and its usage evolves. Conversely, while Coyne and McMickle (2017) confirm that blockchain technologies will aid in cutting costs in several areas in the public accounting profession, they argue that it may not be useful for all facets of financial reporting. Taken together, blockchain represents an emerging area for the profession and presents a burgeoning opportunity for assurance professionals, whether assessing financial reporting or sustainability reporting.

## SUSTAINABILITY

### Sustainability Reporting

The traditional purpose of a corporation has been to maximize the wealth of its shareholders (Friedman, 1970). In August 2019, the CEOs of some of the largest companies

in the world updated this purpose and created a new "Statement of the Purpose of the Corporation" (Bradt, 2019). Although shareholder wealth was still included in the statement, it was listed at the bottom after considerations of ethics, customers, and employees. Notably, attention to the community was included, stating, "We respect the people in our communities and protect the environment by embracing sustainable business practices across our businesses" (Bradt, 2019). Sustainability initiatives have come to the forefront of many businesses and have ultimately resulted in a systematic change in how companies operate. Leading the shift to more wholistic reporting, 83 percent of Canada's largest companies released sustainability reports in 2013 (CPA Canada, 2015). Following the lead of Canada's largest companies, the Governance and Accountability Institute (2019) found that 86 percent of the S&P 500 Index companies reported on their sustainability efforts in 2018. Companies are recognizing the importance of sustainability disclosures.

Sustainability was initially defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). Presently, in the context of a business, it specifically refers to actions and initiatives that companies can take relating to "their environmental, social and economic priorities, policies, programs, and performance" (CPA Canada, 2015). These initiatives encompass a wide range of activities, including greenhouse gas emissions and other energy-related matters, employee satisfaction and retention, use of socially responsible suppliers and vendors, and human rights (Chung and Cho, 2018). Although many companies have supported and practiced sustainable initiatives for years (Chung and Cho, 2018), as evidenced by the Statement of the Purpose of the Corporation, they have recently become more prevalent and critical, particularly in the areas of verified sustainability reporting. Interestingly, a recent report from BlackRock stated that "as investors shift money into sustainable funds, companies that perform well on environmental, social and governance metrics should steadily increase in value and those that do not should fall" (Nauman, 2020). Thus, if investors are seeking to place their money into sustainable investments, it will be integral for companies to release proper reports describing these initiatives that have been vetted and assured by outside parties, such as CPA firms.

While there are currently no reporting requirements regarding sustainability in Canada or the United States, there are several commonly used frameworks that provide companies with guidance. Companies have three options: the Global Reporting Initiative (GRI) Guidelines; Integrated Reporting (IR), as issued by the International Integrated Reporting Council (IIRC); and Environmental, Social and Governance (ESG) Disclosures/Sustainability Accounting Standards Board (SASB) Standards (CPA Canada, 2015). According to the KPMG *Survey of Corporate Responsibility Reporting* (KPMG, 2017), GRI is the most commonly used set of sustainability reporting standards worldwide. This framework comprises several universal standards, including General Disclosures and Management Approach, as well as topic-specific standards, such as Economic, Environmental, and Social (GRI, 2018). Its mission, unlike other sustainability reporting standards (i.e., the SASB), is more focused on a "global community" rather than advising stakeholders in making investment and other business decisions (GRI, 2020).

The second major type of sustainability reporting is IR, which seeks to provide value to corporations through external reporting of various factors, such as governance, performance, and strategies (IIRC, 2013). Essentially, in following IR, a company should be incorporating and practicing sustainability initiatives that become part of its everyday operations and core values (CPA Canada, 2015). Key components of an integrated report include strategic focus, connectivity of information, stakeholder relationships, materiality, conciseness, reliability and completeness, and consistency and comparability (IIRC, 2013). While the IR framework has seen a significant increase in utilization over the past several years, U.S.- and Canadian-based companies have been slower to adopt it. Despite the adoption hesitation, the AICPA and CPA Canada have continued to champion the project and encouraged companies to utilize it (Beal, 2017; Cohn, 2017).

The final set of widely used sustainability reporting standards were developed by the SASB. As iterated in its standards, the SASB's mission "is to develop and disseminate sustainability accounting standards that help public corporations disclose material, decision-useful information to investors" (SASB, 2017). The SASB standards were created primarily for inclusion in SEC reports, such as the Form 10-K annual report, to help a company more accurately estimate its sustainability value financially, as well as nonfinancially (SASB, 2017). The SASB's five main tenets are issues related to the environment, social capital, human capital, business models and innovation, and leadership and governance (SASB, 2017). While the SEC has yet to endorse or adopt the SASB standards in its reporting practices, the SASB has continued to lobby for its standards to be utilized in SEC reports (SASB, 2019).

Each framework requires different levels and types of assurance. Although there is presently a lack of an internationally accepted or standardized framework, in September 2020 five organizations, including the GRI, IIRC, and SASB, as well as the Climate Disclosure Standards Board (CDSB) and the CDP, put forth a joint statement that described how they intend to work together to establish a comprehensive set of sustainability standards (Impact Management Project, 2020). Several other standard-setting bodies and organizations have indicated the need for a standardized framework for nonfinancial information (NFI). For instance, in 2019 Accountancy Europe created a nine-point plan with four approaches to aid in reducing confusion around NFI and sustainability practices (Accountancy Europe, 2019). It is noted that the optimal approach is a global reporting structure. Similarly, Eumedion issued a green paper in 2019 that questioned whether worldwide adoption of sustainability standards is feasible. It also called for the IASB to establish independent and authoritative NFI standards with auditors providing at least limited assurance (Eumedion Corporate Governance Forum, 2019). In fact, in September 2020 the International Federation of Accountants (IFAC) also called for the IFRS Foundation to create an International Sustainability Standards Board (ISSB), which would aid in bridging the gap between the reporting of financial and nonfinancial information (IFAC, 2020). In 2019, the World Economic Forum, in collaboration with the Big 4, developed a proposal known as "Toward Common Metrics and Consistent Reporting of Sustainable Value Creation." The proposal, to create more transparency for shareholders and investors, encouraged consistency of standards across different countries, industries,

and companies with appropriate levels of assurance (World Economic Forum, 2020). The firms followed through on this pledge, announcing in September 2020 that they will commission their own set of ESG standards, further increasing the growing number of standard setters (Tett, 2020).

Although sustainability practices are not new, the reporting surrounding them has come to the forefront of corporate initiatives in recent years and is likely to continue to see increased focus. With this increased exposure, one of the considerations surrounding sustainability efforts being made includes where to house the employees who work in those areas—are they auditors, assurance professionals, or consultants? Additionally, what role will CPAs and public accounting firms play in preparing sustainability reports or providing assurance over sustainability reporting?

## Sustainability Assurance

An AICPA survey of accounting practitioners in both public and private accounting found that not only is there a growing demand for companies to report more corporate social responsibility (CSR) information, but there is a demand for "assurance on this information and the systems and processes used to generate it" (AICPA, 2015: 2). Currently, assurance over sustainability reports utilizing GRI standards is generally at the discretion of the company, but stakeholders and other third parties are more apt to solicit a certain level of assurance for particular sections (Willis, Campagnoni, and Gee, 2015). Similarly, assurance over reports prepared using IR standards is not required, but the IIRC recognizes that reliable sustainability reports utilizing IR standards is critical, especially as more companies begin to adopt them (IIRC, 2015). Last, the SASB encourages companies to ascertain a level of assurance similar to that of other information included in the 10-K (but not at the same level of financial statement audits) (CPA Canada, 2015).

Though voluntary in most countries, providing assurance on sustainability reports is a growing field within the public accounting profession. We have already mentioned the large adoption among the world's largest 250 companies. Within Canada, of the 102 Canadian companies producing reports according to GRI Guidelines, 40 had their report externally reviewed (CPA Canada, 2013). Sustainability assurance can serve to mitigate against the risk of inaccurate or misleading reporting, as well as add credibility to the data and information disclosed (Chung and Cho, 2018).

## Issues with Sustainability Reporting and Assurance

Despite the growth in sustainability reporting and assurance described above, issues continue to arise with gathering and verifying the data presented in the reports. An EY survey of publicly traded and private companies found that the two most reported challenges related to sustainability reporting and the associated assurance process are the availability of data and accuracy or completeness of data (EY, 2016). For example, in Starbucks' fiscal year 2017 responsibility report, the company reported on 15 goals and progress statuses related to CSR initiatives (Starbucks, 2017a). However, the accompanying independent assurance report from MossAdams LLP provides an opinion on only

three of the data points provided in the report (Starbucks, 2017b). Boiral, Heras-Saizarbitoria, and Brotherton (2019: 711) find that auditors' methods for assessing the accuracy of sustainability information are rarely explained in the assurance report, and many focus only on "quantitative indicators that can be verified using recalculation."

Not being able to overcome these systems and data issues is problematic given that the most commonly used standards for sustainability assurance, ISAE 3000,[5] defines evidence as both relevant information contained in information systems or other information, such that the evidence is sufficient in quantity and appropriate in quality.[6] These issues increase the risk that companies continue to self-report unverifiable sustainability information, which in turn could decrease the market's demand for sustainability reporting and initiatives if the information is seen as selective or unreliable. This highlights the need for improved data environments for collecting and maintaining sustainability information.

Traditional ERP systems revolutionized companies' processing and reporting capabilities. ERP "provides a common platform for different organizational departments. . .to act as a unified entity. . .[and] removes physical boundaries, strengthens centralized processes, and globalizes IT architecture" (Banerjee, 2018: 71). These features appear well suited to enable organizations' existing ERP systems to solve the issues with sustainability reporting.

However, many ERP systems cannot connect one organization to another and create a network among varied partners and stakeholders, which is problematic in a world of increasing globalization (Banerjee, 2018). Dai and Vasarhelyi (2017) discuss how the centralized platform and risk of manipulation in ERP systems contrasts with the decentralized, immutable nature of blockchains, which reduce the risks of a single point of failure. However, ERP's functionality as an accounting ledger would not be replaced, but rather enhanced, with blockchain. Utilizing a blockchain to connect portions of multiple stakeholders' ERP systems would allow organizations to both benefit from existing technology and harness the power of new technology to communicate and share information. Blockchain technology can enable companies that report on sustainability and the firms providing assurance on these reports to overcome current issues with this information. "Blockchain has the potential to transform both sustainability reporting and assurance, helping companies manage, demonstrate, and improve their performance while enabling consumers and investors to make better-informed decisions" (PwC, 2018: 7).

## Blockchain's Enhancement of Sustainability Reporting and Assurance

After discussing blockchain's potential in sustainability reporting, we now discuss limitations within sustainability reporting, supply chain operations, and assurance and how

5. International Standard on Assurance Engagements (ISAE) 3000 and the Institute of Social and Ethical Accountability (AA) 1000 are the most well known and applied standards for sustainability reporting. ISAE 3000 was not explicitly developed for sustainability engagements; however, these types of engagements fall under its scope (Boiral, Heras-Saizarbitoria, Brotherton, and Bernard, 2019).
6. This is consistent with Canadian Auditing Standard (CAS) 500, which requires an auditor to consider the relevance and reliability of information used as audit evidence.

blockchain, in conjunction with existing systems, can facilitate solutions to these issues. Where applicable, we also describe real-world use cases. Table 1 provides a summary of these limitations and potential solutions.[7]

Certain sustainability information requires collaboration across multiple external parties, such as parties along a supply chain. For consumer product companies, tracing inventory through the supply chain has grown into one of the most important sustainability reporting areas, with heightened attention related to product provenance. However, significant roadblocks to data sharing among different stakeholders cause challenges to efficient and accurate reporting of sustainable supply chain information (Tan, Wang, Liu, Kang, and Costa, 2020). Siloed data that exist within each party's ERP system along the supply chain limits the ability to have real-time tracking updates, creates data redundancy, and increases the risk of data errors, especially when manual intervention may be required. A challenge for companies and their auditors is tracing and identifying the source, as well as the chain of custody for products, particularly in instances in which several suppliers may be involved (Alali and Wang, 2018).

A blockchain-based supply chain can improve the process and store the features of products, such as their quality, quantity, location, and ownership at any given moment (Saberi, Kouhizadeh, Sarkis, and Shen, 2019). Applicable portions of each entity's ERP system can be connected on a blockchain to facilitate standardized sharing and tracking of this product information (Banerjee, 2018). Thus, a blockchain would remove the traditional silos that exist around individual company data as it relates to inventory and supply management.

However, with data collection and reporting occurring across multiple disparate parties, there continues to exist the risk that characteristics, measurements, and other identification information become nonstandardized or incomplete if there is no enforcement mechanism to ensure all necessary information is gathered and entered correctly. For example, to certify the sustainable nature of the wood used in its products, furniture manufacturer IKEA must trace the wood from harvesting to final production while utilizing the wood products' industry certification and labeling system (Dabbs, 2017). However, with different certification organizations and different harvesters involved in the process, the number of intermediaries and situations for data error or manipulation grows. As noted by Banerjee (2018: 74), a distributor's ERP system may refer to a product as X, a customer's ERP may refer to the same product as Y, while the supplier's ERP system labels it Z, resulting in "every supply chain transaction that happens across enterprises carrying these cross references." Additionally, one entity may not collect and report certain data about product provenance that is needed by the next organization on the supply chain.

Implementing blockchains' self-enforcing smart contracts can address this issue by requiring certain elements of data collection before a block of information can be added to the chain (Dai and Vasarhelyi, 2017). While advanced technologies such as IoT devices and RFID tags can be linked to one entity's internal ERP system, the information remains siloed as it moves from one party to another. Individual parties along the supply

7. Naturally, not every issue within sustainability is solved by adopting blockchain technology, nor is the adoption of blockchain an immediate solution. We discuss these specific limitations to blockchain adoption in the next section.

**TABLE 1**
Blockchain to enhance sustainability reporting and assurance

| Issues in sustainability reporting and assurance | Potential blockchain solution |
|---|---|
| **Siloed data**: Each entity's ERP system is centrally organized and does not integrate with outside parties (Dai and Vasarhelyi, 2017). | Applicable portions of each entity's ERP system can be connected to one blockchain to facilitate standardized sharing and tracking of information (Banerjee, 2018). |
| **Incomplete data**: Data collection across multiple, disparate parties could quickly become nonstandardized. Characteristics, measurements, and other identification issues could arise if there is no enforcement mechanism to ensure all necessary information is gathered. | Self-enforcing smart contracts can be implemented requiring certain elements of data collection before a block of information can be added to the chain (Dai and Vasarhelyi, 2017). These smart contracts can also be linked with asset ID tags and IoT devices to further facilitate tracking and traceability (Sheldon, 2020). |
| **Challenge for assurance providers to verify completeness of sustainability information:** Often sustainability assurance reports focus on assessing accuracy of data transfer from existing ERP systems, or even basic data collection systems, such as Excel, to sustainability reports and do not focus on completeness of data (O'Dwyer, 2011). | In conjunction with the discussion above, the blockchain solution can deploy validity checks, using smart contracts, as part of the consensus mechanism to ensure that only complete transactions post to the blockchain. Local distributed copies of the blockchain ledger allow nodes to check the completeness and accuracy of transactions (Rozario and Thomas, 2019). |
| **Simultaneous physical and digital asset tracking**: While IoT and asset ID tagging can be linked to the internal ERP system, as this information moves from one party to another the information cannot be connected across multiple parties' ERP systems. Individual parties along the supply chain also cannot link IoT devices to proprietary ERP systems. | Various users can utilize IoT devices and asset ID tags to update information stored on the blockchain (Sheldon, 2020). This information can link to data stored on ERP systems to match and track assets (Lin et al., 2018). |
| **Incentivizing and tracking participation by external parties to report sustainability information**: Many external individuals or small organizations may provide sustainability data along a supply chain. The end reporting organization is unable to verify or incentivize participation by these entities to track sustainability information. | Each entity in the network becomes a miner on the blockchain and is rewarded to maintain the network (Holden and Malani, 2019). |
| **Risk of data manipulation to "greenwash" information**: Risk of override of management controls is higher given extensive human labor-intensity (Dai and Vasarhelyi, 2017). | Consensus mechanisms within the blockchain system and append-only nature lower the risk of override (Dai and Vasarhelyi, 2017). |

(The table is continued on the next page.)

**TABLE 1** (continued)

| Issues in sustainability reporting and assurance | Potential blockchain solution |
|---|---|
| **Complying with multiple regulatory agency and auditor requests for information**: Centralized, nondistributed nature of existing systems prevents outside access. | Blockchains allow the ability to include read-only nodes with access to reporting information, reducing time spent on compliance. Smart contracts can help to define the interaction between network participants and with the blockchain system (Saberi et al., 2019). The auditor benefits from being able to verify reliability of audit evidence through direct observation. |
| **Demand by investors for real-time information regarding reliability of sustainability information**: Traditional audit procedures on voluminous transactional data from an ERP system cannot provide real-time assurance (Dai and Vasarhelyi, 2017). | Blockchains enhance auditors' ability to trust the integrity of sustainability data, enabling them to perform real-time analyses and assurance procedures (Dai and Vasarhelyi, 2017). |

chain cannot typically link IoT devices to proprietary ERP systems. However, a blockchain can place what are typically viewed as physical assets (e.g., inventory) into an immutable distributed ledger and then use smart contracts in conjunction with IoT and RFID to automatically update the blockchain as goods are tracked through various locations, thereby linking physical products with their virtual blockchain identity (Saberi et al., 2019; Sheldon, 2020). This information can link to data stored on individual ERP systems to match and track assets (Lin, Shen, Zhang, and Chai, 2018).

In turn, this addresses one of the main issues in sustainability assurance, which is verifying the completeness of sustainability information. O'Dwyer (2011: 1246–47) identifies that a majority of sustainability assurance reports focus on assessing the accuracy of data transfer from existing ERP systems, or even "rudimentary systems. . .such as Excel" and ignore assessing the completeness of the data. The blockchain solution can deploy validity checks, using smart contracts, as part of the consensus mechanism to ensure that only complete transactions post to the chain. Local distributed copies of the blockchain ledger allow nodes to check the completeness and accuracy of transactions (Rozario and Thomas, 2019). Additionally, adding the use of cryptographic signatures by participating parties would improve authenticity and further enhance accountability. A blockchain-based solution would "open up the whole tracking process to scrutiny while at the same time preventing any monopolistic third party from controlling the system" (Dabbs, 2017). Then, when IKEA cites that 85 percent of its wood comes from more sustainable sources in its sustainability report, its third-party assurance provider can more easily trace and verify this assertion and include it in its report (IKEA, 2018).[8]

8. IKEA's FY18 sustainability report contains an assurance report from EY (IKEA, 2018). The limited assurance engagement only provides a conclusion on the carbon emissions statement and no other reported information.

In another example, Volvo has partnered with leading technology companies to adopt a blockchain for cobalt, a key mineral in batteries sourced from the Democratic Republic of Congo. Volvo's blockchain contains information about the minerals' origin, size, weight, and chain of custody (Reuters, 2019). This blockchain solution "gives a commodity a dynamic identity, or dynamic twin, so that it can be tracked along the supply chain journey, from source to consumer, even if the commodity changes on the way" (Sloane, 2020). Along with information about the minerals, additional information can be uploaded to the blockchain to track if fair labor standards are also being adhered to, ensuring that suppliers are not using child labor and fair wages are being paid, addressing the social element of sustainability reporting.

Similar to the growth in reporting on conflict minerals,[9] the importance of reporting on carbon or greenhouse gas emissions is growing as more regulatory bodies assert standards and rules. Tang and Tang (2019) find that a blockchain-enabled distributed carbon ledger can more effectively manage carbon emissions trading and manage carbon assets and liabilities. Their study forecasts that the use of blockchains in addressing the issue of climate change is likely to advance in the coming years to fulfill a role that traditional ERP systems cannot accomplish. Similarly, Dai, He, and Yu (2019) discuss how blockchains and smart contracts can be used to facilitate an accountability audit of air pollution control in China. A blockchain-based platform could enable cryptographic tokens to contain a tradable value, optimizing carbon (or other) credits and minimizing issues with double counting. In conjunction with these tokens, smart contracts can access real-time, trustworthy data which increase transparency, auditability, and credibility (PwC, 2018).

As with most reporting systems, the output of a blockchain is only as strong as the inputs. However, as supply chains grow in size, the end reporting organization may have limited contact with the various parties participating to provide and verify data. If the end reporting organization is unable to easily verify or incentivize participation by other entities to track sustainability information then the lack of accountability could lead to failures to comply with tracking and lead to inaccurate sustainability data. However, if these parties' participation and performance were incentivized and tracked on a blockchain, the risk of data inaccuracies would be minimized. For example, to incentivize fishermen to provide information on their catches, FishCoin developed a utility token that is tradable for mobile phone usage credits (PwC, 2018). Thus, parties along the supply chain become *miners* on the network. "In a well-functioning blockchain-based ledger, parties can trust the miners to honestly maintain the network because blockchain gives miners a reward or compensation for maintaining the network" (Holden and Malani, 2019: 6). Not only does this improve sustainability reporting of environmental and issues, it also allows a company to address social issues by fairly compensating stakeholders for participation in the blockchain supply chain. Combining these incentives with smart contracts programmed with rules of tracking, regulatory policy, or sustainable terms enhances the quality of data produced by the blockchain (Saberi et al., 2019).

9. The SEC requires issuers to disclose their efforts in determining the origination of minerals used in their products when sourced from mines in conflict areas in sub-Saharan Africa.

In interviews of those providing assurance over sustainability reports, Boiral, Heras-Saizarbitoria, Brotherton, and Bernard (2019) found that the information collected for verification is controlled by reporting organizations and that information may be voluntarily disclosed or filtered by companies. In traditional ERP systems, the risk of override of management controls is high given the extensive manual usage these systems require (Dai and Vasarhelyi, 2017). With increasing pressure to report sustainability information, managers may be driven to manipulate or greenwash this data in an ERP system. The consensus mechanisms within the blockchain system, requiring validation by the nodes in the network before a block is added, as well as the append-only nature of blockchains, lowers the risk of override and provides value separate from the ERP system (Dai and Vasarhelyi, 2017).

The pressure to report sustainability information arises from the extensive number of regulatory and ratings agencies' requests for information, as well as requests from the external auditor. CPA Canada (2019: 54) finds that "a multi-million-dollar industry already exists around environmental, social and governance ratings, which are used by assets managers and investors in assessing the sustainability of their investment companies." There is extensive duplication of efforts among various certifying bodies to collect sustainability information from companies. For instance, one Finnish company, UPM Biofuels, needs to be certified by three different regulatory bodies related to its biofuel production, resulting in repeated efforts and costs by regulatory auditors and company employees (Roundtable on Sustainable Biomaterials, 2018). However, if information regarding its supply chain or production process were made available on a blockchain, rather than responding to each auditor's requests, the company can grant the various auditors and regulators access to participate as read-only nodes on the blockchain. Certifying bodies, and ratings agencies, could then collaborate and develop a single ledger with automatic data collection and management to increase data transparency and authenticity while minimizing compliance costs (PwC, 2018).

Additionally, Lackmann, Ernstberger, and Stich (2012) found that investors take into account the reliability of sustainability information when determining the market value of a company by examining the external sustainability assurance report, among other items. With the growth in index funds linked to CSR performance, investment companies are continuously monitoring the components of the index by examining new evidence as to the reliability of companies' sustainability information (Lackmann et al., 2012). Unlike traditional audit procedures used on voluminous transactional data from an ERP system (Dai and Vasarhelyi, 2017), the use of blockchain technology in sustainability reporting allows for real-time assurance by external auditors. As Dai and Vasarhelyi (2017) note, due to the secure nature of data that enters the blockchain, auditors can trust the integrity of the data, enabling them to perform real-time analyses and assurance procedures. Additionally, with the increased reliability of sustainability data on the blockchain, auditors' role could shift toward assessing the effectiveness of the design of controls within the blockchain ecosystem (Dai and Vasarhelyi, 2017).

The disintermediation of the blockchain, allowing external auditors and regulatory agencies to participate, is further enhanced by the use of smart contracts. As Saberi

et al. (2019) find, smart contracts can help to define the interaction between network participants and with the blockchain system. "Smart contracts may be especially capable for rules of tracking and controlling sustainable terms and regulatory policy autonomously and enforcing or governing appropriate corrections" (Saberi et al., 2019: 2122), ultimately reducing compliance costs and data redundancy.

These cases and uses are some of the many areas in which blockchain technology can be, or is currently being, utilized to enhance sustainability reporting. If blockchain is implemented to assist companies in producing information about sustainable supply chains, production processes, or labor practices, this could, in turn, increase the ability of third parties to provide assurance on this information. Kokina, Mancha, and Pachamanova (2017: 95) find that "the ability to track, through a distributed ledger, the true value of the products and services that customers purchase as well as factors such as environmental damage, child labor, and criminal activities that potentially go along with the manufacturing of products, can be disruptive for the industry and lead to the formation of an open ecosystem for collaboration." The growth in sustainability reporting and the use of blockchain can be combined to provide more relevant and transparent information on environmental, social, and governance issues to interested stakeholders.

## LIMITATIONS AND OPPORTUNITIES FOR FUTURE RESEARCH

Despite its many benefits, the implementation of blockchain has limitations. We highlight a few of these, recognizing that, as with the use cases above, the emerging nature of this technology brings about constantly changing developments. First, while blockchain can address many of the issues with sustainability data, there are some problems for which blockchain is not the solution. O'Dwyer (2011) highlights the difficulties and limitations in applying traditional financial audit techniques without well-established standards to what at times can be ambiguous and qualitative data. For example, interviews with assurance personnel indicate that language within a sustainability report indicating a company "implemented human rights policies" causes challenges for auditors to first agree upon definitions of these terms and then to "develop assurance procedures tailored to assessing 'implementation' in the context of these definitions" (O'Dwyer, 2011: 1246). These types of situations rarely arise in a traditional financial audit with standardized language, definitions, and procedures. This issue is not easily solved with either existing systems or blockchain.

A second limitation is that parties must be willing to invest the money, time, and human capital to develop a blockchain-based solution that will satisfy the issues with the currently existing infrastructure and information systems. Future researchers would benefit from bridging the gap to this limitation with a comprehensive assessment of the net benefits, economic and otherwise, of using blockchain to achieve companies' operational goals while improving the quality of their reporting. This would include internal and external costs and benefits. For instance, competitors may need to be willing to collaborate to create consortiums so that meaningful enough quantities of data can be shared, such as along a supply chain or with regulatory bodies. Issues related to ensuring compliance with privacy rights and clarifying accountability should concern arise remains

relevant even with the cryptographic and immutable nature of the blockchain (PwC, 2018). Once researchers and firms reporting on sustainability efforts have a greater understanding of the totality of benefits and externalities, the full potential of blockchain and its various use cases will be better understood.

As blockchain participants and data grow, questions as to scalability arise as certain blockchain applications are computationally intensive (Kokina et al., 2017). The computational power required of some blockchains naturally leads to questions about energy consumption. In applying blockchain for sustainability reporting, it would be irresponsible to ignore such an issue. However, many private blockchains implemented at the enterprise level, as described in this article, generally do not run into these issues to the same degree as large-scale public blockchains. Nevertheless, it is an issue that should be further researched, both within the context of applying the technology for sustainability and in the broader blockchain context.

Last, as previously iterated, this article is not meant to serve as a technical implementation guide. However, future research should explore more in-depth adoption of blockchain within specific elements of sustainability reporting, including the mechanics underlying its execution. Similarly, additional research should explore the more detailed procedural steps that assurance providers can take to gain an understanding of the evidence provided by a blockchain, including how blockchain fits into the general information technology controls within an organization. Further exploration of blockchain consortia and the potential role of service organization control reports is also relevant in the area of sustainability information.

## CONCLUSION

Blockchain technology is uniquely positioned to see a growth in adoption at the same time public companies are placing a greater emphasis on sustainability reporting and searching for reliable mechanisms to provide sustainability information to shareholders and the general public. Coincidentally, 86 percent of business executives in Deloitte's (2019) survey see blockchain as providing new functionalities to their business, while at the same time 86 percent of S&P 500 corporations are reporting on their sustainability efforts (CPA Canada, 2015; Deloitte, 2019).[10] Presently, the majority of sustainability reporting is voluntary and difficult to confirm by assurance professionals. The potential for companies to use blockchain to improve their sustainability reporting, in coordination with existing ERP and accounting information systems, seems like a logical extension for companies already considering implementing blockchain in other aspects of their business.

Within sustainability reporting, we see blockchain as being well positioned to provide reliable tracking and custodial support on top of the capabilities in existing ERP

10. We recognize that the Deloitte (2019) blockchain survey and the 2019 report by the Governance and Accountability Institute did not utilize similar samples. However, it would also be unsuspecting to assume that considerable overlap between the two reporting entities—those considering adopting blockchain technology and those reporting on sustainability—did not exist.

systems, as it relates to sustainability information such as conflict mineral disclosures required by the SEC and greenhouse gas emissions that are being self-reported by many Canadian and U.S. firms. Because sustainability reporting and blockchain are both relatively new to the assurance reporting space, companies could implement blockchain into their sustainability reporting now and avoid the switching costs, learning curves, and disruptions that will come if they delay adoption.

While adopting blockchain for sustainability reporting is subject to the limitations and will not solve all the issues in verifying sustainability reports, it would provide companies looking to improve the quality of the information in their sustainability reports with a reliable platform to compile and track their reporting. Blockchain would give auditors and other assurance professionals more trustworthy evidence with real-time third-party verification. Sustainability reporting and the assurance services associated with those reports are only likely to expand as more high-quality evidence is demanded by regulators and shareholders. The use of blockchain can help meet that growing demand for companies and assurance professionals alike.

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