EXPLORING BLOCKCHAIN FOR MANAGEMENT ACCOUNTING AND CONTROL

Abstract

Blockchain's core features – transparency, immutability, and decentralized trust – fit well, in-principle, with requirements of management accounting and control (hereafter, accounting) processes. Smart contracts, Internet of Things (IoT), and alternative shared ledgers can enhance accounting processes without a blockchain, especially when participants know each other and a central authority exists. Considering blockchain failures and myths, management accountants should critically assess blockchain's fit with proposed applications.

Myles Stern
Lecturer
Lamden School of Accountancy
Fowler College of Business
San Diego State University, San Diego, California
mstern@sdsu.edu

Alan Reinstein
George R. Husband Professor of Accounting Emeritus
Mike Ilitch School of Business
Wayne State University
Detroit, Michigan
aa1692@wayne.edu

CMA Akhilesh Chandra
Academic Consultant and
Professor of Accounting and Accounting Information Systems, *Retired*
Akron, Ohio
ac10@1870.uakron.edu

Objective

Since Bitcoin's 2009 advent, many domains have embraced blockchain technology to provide visibility, transparency, irreversibility, immutability, and security of data records. Originally developed to record bitcoin cryptocurrency transactions in a publicly shared distributed ledger, we show blockchain's importance for accounting processes. We review blockchain's purpose, underlying technology, limitations, and myths; focusing on (1) blockchain's fit with accounting, (2) accounting processes suitable for blockchain application, and (3) blockchain alternatives for other accounting processes not matching blockchain's features. Using academic and practitioner literature insights, we develop (1) a conceptual basis for blockchain applications in accounting processes and (2) a blockchain decision rule for accounting professionals.

Blockchain Concepts

Blockchain uses blocks linked on a chain to store, efficiently maintain, seamlessly replicate, and securely share digital data within a peer-to-peer network. As a shared digital distributed ledger,

blockchain ensures decentralized security and trust among participants.

Blockchain's cryptocurrency support includes providing a trusted single source of truth; managing potentially untrustworthy, anonymous participants; preventing double-spending; offering divisibility (i.e., "making change"); and confirming each transaction's anonymous originators. A blockchain (1) verifies, records, and preserves transactions; (2) combines transactions in blocks; and (3) cryptographically links blocks to immediately reveal any change to a transaction. Blockchain fits well for processes with requirements like crypto-assets. Alternative shared ledgers, using some blockchain features, may work better for other processes.

Technological Bases

Core Technology

Blockchain uses (1) no central authority; (2) cryptographic signatures to conclusively tie a transaction to its originator without revealing that signatory's identity; (3) a consensus mechanism to add new transaction blocks on the chain; and (4) a cryptographic hash of the current block's contents and prior block's hash to tie each block to its predecessor and successor.

The hashing algorithm mathematically transforms a variable-length input message into a fixed-length digital fingerprint. Blockchain's timestamp feature ensures data validity during block creation. Together, cryptographic hash value, data timestamp, and actual data within each block make blockchain transactions irreversible. Retroactively modifying a block's data invalidates that and all succeeding blocks' hashes, thus immediately revealing the modification.

Related Technologies

Organizations can use blockchain with other technologies. A *smart contract* is a self-executing program stored on a blockchain that a transaction added to that chain triggers. Its applications include compliance with accounting principles, paying suppliers upon merchandise delivery, enabling decentralized finance (DeFi) to offer financial services without using conventional financial intermediaries, and making intellectual property royalty payments.

IoT is an Internet-enabled network of physical objects embedded with sensors and software to communicate and automate tasks. IoT is vulnerable to cyber-attacks and data tampering with storage, process and access. Blockchain can minimize IoT vulnerabilities by securely storing data while assuring its legitimate sources.

Blockchain Myths

A blockchain is immutable

A blockchain is immutable if no one person controls over half the computing power (called the *hashrate*) to add blocks to the chain. Blockchains with few participating network nodes can suffer "51% attacks." Bitcoin requires *all* its technology components to assure immutability and prevent double-spending. Often blockchain's business applications relax some features, e.g., a different consensus mechanism to add blocks, thus, threatening immutability. Hence, each blockchain application should justify how it preserves immutability.

A non-blockchain-ledger lacks immutability

Non-blockchain trusted shared ledgers may duplicate data on multiple network nodes and use non-blockchain mechanisms to prevent unauthorized data modifications. An enterprise resource planning (ERP) system uses a centralized server stored database and can limit some network nodes to append-only access. A non-blockchain shared ledger can securely log all transactions to prevent unauthorized changes to posted transactions.

A smart contract requires a blockchain

Smart contracts "autonomously verify, enforce, and execute" contracts' terms. Any secure and reliable shared ledger – not just a blockchain – can store and run smart contracts.

Blockchain Implementations

Blockchain implementations have evolved from Bitcoin's launch to non-cryptocurrency uses. Blockchain proposals are often opaque, inadequately explain the application's purpose, describe neither the blockchain's function within the application nor its configuration, and quietly abandoned.

Notable applications

DeFi generally and many cryptocurrencies particularly are among successful blockchain applications. Non-fungible tokens (NFTs) often use cryptocurrencies for payment. An NFT represents a unique digital or physical asset, such as artwork (physical or digital), a company's stock shares, or a vehicle. DeFi and NFT applications share many cryptocurrency characteristics, including no central authority and unknown participants.

Some blockchain failures

Lack of fit with use case requirements and implementation complexity are the primary reasons for failed blockchain projects. Organizations must solve business problems, not seek applications for a new technology. We identify prominent blockchain failures cited in academic and practitioner literature that support this conclusion. A comprehensive list of failed blockchain projects is beyond the scope of this research.

Maersk and IBM launched TradeLens in 2018 to exchange container shipments' data, but scrapped it in 2022 for commercial viability concerns.[1] The Australian Securities Exchange announced a blockchain-based clearing system in 2017 but cancelled it in 2022 citing 'solution uncertainty.' In 2018, Santander Bank launched One Pay FX, a blockchain-based payment system that morphed into blockchain-lacking PageNxt, and was eventually discontinued in November 2021. IBM's Food Trust blockchain to track Walmart's leafy vegetables' provenance saw limited success, adding only green bell peppers since its inception.

Applications incompatible with blockchains' features can use alternative shared digital ledgers. Thus, different healthcare systems shun blockchain to share patient data because (1) of non-anonymous patients and providers, (2) of medical records' complex data structure, (3) erroneous entries must be corrected, and (4) each healthcare system is a central authority responsible for its own data. Non-blockchain ledgers can still use hashing and digital signatures.

A blockchain decision rule

Cryptocurrencies, other crypto-assets, other DeFi applications, and NFTs share these characteristics: (1) no central authority, (2) unknown and untrusted participants, (3) transaction immutability, and (4) a simple data structure. Management accountants will often face these blockchain uses and must grasp blockchain fundamentals to assess value and internal controls. Our blockchain decision rule is simple. If a proposed accounting use lacks one or more of these characteristics, we recommend using an alternative shared ledger.

Management Accounting: Potential Use Cases

Blockchain's fit with accounting processes

Managers should establish blockchain's viability vis-à-vis an application's business problem, needs, features, and constraints. Focusing on the business problem and its characteristics avoids the trap of a technical solution seeking a business problem.

Given a market-driven sales price, seeking a target profit requires cost management, necessitating seamless sharing, visibility and transparency of costs across the supply-chain. Thus, automotive and electronics industry share parts' traceability and receipt with supply-chain partners for just-in-time manufacturing. Retail chains share stock and sales data with suppliers for just-in-time inventory replenishment. Wholesalers' and retailers' e-Commerce sites share prices, stock levels, and delivery dates with customers. Such applications' features include known participants, the original-equipment-manufacturer (OEM) as a central authority, and complex data structures. Alternative shared ledgers can reduce costs and improve processes in applications using EDI, inter-firm ERP connections, or displaying the OEM's production schedule at suppliers' plants.

Potential management accounting applications

We consider two accounting process categories for potential blockchain applications: internal (within an organization) and inter-firm (between organizations). Within each category, we identify representative processes for blockchain or alternative shared ledger applications. Internal processes, with the firm as the central authority and known users, will likely use an alternative shared ledger. Some inter-firm processes may have all four decision-rule characteristics and thus fit a blockchain. Other inter-firm processes require an alternative shared ledger.

Credit Approval (internal)

A smart contract running on an alternative shared ledger (probably the firm's ERP system) can approve credit or add new customers or suppliers. A smart contract can (1) make blockchain-based letter-of-credit payments; (2) verify compliance with contract terms; (3) check materials receipt; and (4) enforce compliance with internal policies, industry-specific standards, and government regulations.

Inventory Visibility (internal and inter-firm)

A shared ledger provides real-time inventory movement and balance across the supply-chain to optimize inventory, avoid stock-outs, facilitate just-in-time purchases, improve demand forecasts, improve inventory replenishment, and increase revenues. Sharing product design requirements across the supply-chain helps direct and downstream suppliers join product development efforts to lower material costs, enhance innovation, improve quality, reduce time-to-market, and enhance customer satisfaction.

Risk Management (inter-firm)

Supply-chains face disruption risks from natural disasters, geopolitical instability, cyber-attacks, pandemics, and supplier bankruptcies. A shared ledger can (1) improve risk management, disaster avoidance, and recovery; and (2) provide data for inventory, shipment, and supplier operations including status, lead times, capacities, and transit routes.

Single Source of Truth in the Supply Chain (inter-firm)

A shared ledger provides visibility to efficiently update digital records. Efficiencies and cost reductions accrue with only occasional reconciliation needed of a firm's internal data with supplier and customer reports.

Visibility into End-Product's Usage of Suppliers' Inputs (inter-firm)

A parts supplier can use a shared ledger to see how the final product uses its output. Consider Supplier A making a bracket that Supplier B attaches to a seat assembly that Company C installs when assembling a finished vehicle. Knowing the bracket's end-use, Supplier A could redesign it to lower its cost (reducing raw material cost to both B and C) and simplify its attachment to the vehicle (reducing Company C's labor cost).

Mitigate Bullwhip Effects (inter-firm)

The 'bullwhip effect' refers to small fluctuations in retail consumer demand improperly increasing demand variations at wholesale, distributor, and manufacturer levels. Sharing real-time sales and inventory counts, upcoming promotions, and pricing strategies can mitigate the bullwhip effect by aligning upstream demand with end-customer demand enabling collaborative forecasting and planning among supply-chain partners.

Asset Valuations (internal and inter-firm)

Management accountants can help measure organizational cryptoassets used for transactions, held for investments, or used in DeFi activities. Increased revenues at lower costs can arise from new online marketplaces for goods and services created by shared ledgers or from digital tokens (e.g., NFTs) of merchandise or other physical assets.

Caveats

Non-cryptocurrency blockchain applications have limitations. Research suggests that blockchain technology is often expensive to scale and inadequate to address data security or privacy risks. High data modification costs, implementation complexities, slow speed for large-volume transaction verification and consensus effort exemplify blockchain's disadvantages. When sharing data across the supply-chain with known trading partners, shared ledgers may avoid blockchain due to such non-cryptocurrency characteristics as (1) the OEM is a central authority; (2) participants know and trust each other; and (3) shared data's complex structure with multiple interrelated tables. Thus, management accountants should carefully evaluate blockchain's suitability in proposed applications.

Conclusions

Blockchains and alternative shared ledgers can enhance accounting processes. Management accountants should grasp blockchain applications for cryptocurrencies, other crypto-assets, DeFi,

and NFTs. Where user requirements differ from those of cryptocurrencies, alternative shared ledgers may prove useful. Smart contracts can automate processes, facilitate payments, and assure policy compliance.

Our three contributions to the literature are (1) identifying lack of fit with use case requirements as a primary cause of blockchain implementation failure, (2) providing criteria to help management accountants consider using blockchains and alternative shared ledgers for many accounting processes, and (3) a clear decision rule for blockchain applications. In short, a blockchain fits if an accounting application has (1) no central authority, (2) unknown and untrusted participants, (3) transaction immutability, and (4) a simple data structure. Other accounting processes may benefit from an alternative shared ledger. Management accountants should seek to match their application requirements with the proper proposed shared ledgers. MA

Endnotes

[1]*Pope, K. P. and Black, L. "Understanding Blockchain," Strategic Finance, March 2023, 38-45.*

[2]*Dai, J. and Vasarhelyi, M. A., "Toward Blockchain-Based Accounting and Assurance," Journal of Information Systems, 2017, 31 (3): 5–21.*

[3]*Appelbaum, A., Cohen, E., Kinory, E., Smith, S. S., "Impediments to Blockchain Adoption," Journal of Emerging Technologies in Accounting (2022) 19 (2): 199–210.*

[4]*Wragg, E. "Maersk and IBM pull the plug on TradeLens," Global Trade Review, November 29, 2022.*

[5]*Hanisch, M., Roozen, P., & Theodosiadis, V. (2026). Success and Failure in Blockchain-Based Interorganizational Ecosystems: A Governance Perspective. Journal of Management, 01492063261420752.*

[6]*Crawley, J. "Australian Securities Exchange Cancels Blockchain-Based Clearing System at $168M Cost, CoinDesk, May 9, 2023.*

[7]*Frerichs, P. "Blockchain is not Revolutionizing the Supply Chain yet," Global Trade, December 23, 2022.*

[8]*Kohli, R., & Tan, S. S. L. "Electronic health records," MIS Quarterly (2016), 40(3), 553-574*

[9]*Chang, S., E., Chen, Y., and Wu, T. "Exploring blockchain technology in international trade: Business process re-engineering for letter of credit," Industrial Management & Data Systems 2019, 119 (8): 1712-1733.*

[10]*Chopra, S. and Sodhi, M. S., "Reducing the Risk of Supply Chain Disruptions," Sloan Management Review, Spring 2014.*

[11]*Wieland A., and Wallenburg, C. M. "Dealing with supply chain risks: Linking risk management practices and strategies to performance," International Journal of Physical Distribution & Logistics Management, 2012, 42 (10).*

[12]*Lee, H. L., Padmanabhan, V., and Whang, S., "The Bullwhip Effect in Supply Chains," Sloan Management Review Spring 1997, 38: 93-102.*

[13]*Pal, A., Tiwari, C. K., and Haldar, N., "Blockchain for business management: Applications, challenges and potentials," The Journal of High Technology Management Research, 32 (2), November 2021, 100414.*

At the Helm!!!

CMA Santanu Saha

Our Heartiest Congratulations to CMA Santanu Saha who assumed charge as the Director (Finance) at the National Council for Cooperative Training (NCCT), the training wing of the Ministry of Cooperation, Government of India. He is having more than 2 decades of experience in Corporate Finance, Taxation, Audit & compliance and Costing & Budgeting. His previous assignment was as Director-Finance with Quality Council of India, an autonomous body Under Ministry of Commerce & Industry, Government of India. Prior to that, he was engaged with PSU sector in Aviation and Heavy Industries. In addition, he has remarkable exposure with global multinationals like, Nokia and Bank of America in his earlier assignments.

We wish CMA Santanu Saha the very best for all his future endeavours.