Are we contributing? The who, when, where, and what of the Blockchain research landscape

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Abstract

The blockchain technology discourse is diverse, and diffusion is increasing. It is estimated that USD39 billion will be spent within the blockchain ecosystem by 2025. One can view this as an exciting time to be involved in technology. Or another can potentially view this as wasteful spending and exploitation of scarce resources. Additionally, projects and start-ups fail at an alarming rate, making it critical to provide tools to aid decision-makers. Current blockchain research has not yet answered what blockchain is nor what situations it is best suited to.

This paper problematises the current discourse on blockchain technology through a systematic literature review using bibliometric techniques. We present blockchain research on who, when, where, and what. This research also extends the multi-discipline discourse by synthesising how blockchain technology is enacted. We present a benchmarking tool for assessing solutions. Further research topics are also presented.

Keywords: Blockchain, Literature Review, Bibliometric analysis, Distributed Ledger Technology (DLT).

1. Introduction

The Blockchain (and associated Distributed Ledger) technology discourse is diverse. According to Miranda et al. (n.d.), blockchain technology will continue to be diffused even with diversity, ambiguity, and conflict. However, some view blockchain technology as a solution just looking for a problem (Fridgen et al., 2018). While others are concerned about sustainability and the costs associated with running such computationally complex systems (Giungato et al., 2017; Kannengießer et al., 2019, Kugler, 2018). With such ambiguity and potentially high costs, should diffusion continue? Rather than simply expressing excitement about the new, perhaps we should be more rational in our decision-making relative to this technology.

As this research began, it was never the intention to problematise (Alvesson & Sandberg, 2011), feeling there were plenty of research opportunities. However, there was a perceived variation between what was observed within the industry and what was being published in academic research. It was felt that the current research was limited due to two key underlying assumptions. First, the discourse of "blockchain technology" has not evolved similarly to its enactment causing **enactment variation** (potentially due to publication cycles or by not getting close enough to the phenomenon). And secondly, many prototype solutions either present the shortcomings of the Bitcoin Blockchain (and suggest improvements) or test the technology's suitability for a particular business problem, without assessing against other viable (existing) solutions and, by extension, are not assessing the phenomenon within a specific context causing **contextually based phenomena variation**.

For example, Miranda et al., (n.d.) assessed the diffusion of blockchain technology through discourse analysis by including individuals that were self-identified blockchain experts on LinkedIn. Perdana et al., (2021) also explained the diffusion of Distributed Ledger Technology (DLT) through Twitter data analysis. Both these approaches assumed that truth could be found through these methods. These researchers successfully answered their research questions but studied the phenomenon of blockchain diffusion from the context of LinkedIn and Twitter. As researchers, we sought to get closer to the phenomena and address these two assumptions (**enactment variation** and **contextually based phenomena variation**) by determining how blockchain technology was enacted.

In May 2018, a research team member was able to attend Consensus, one of the leading industry conferences. Observations included Lamborghinis dropping off attendees every day, significant attendance from representatives from Family Wealth investors, and big after-parties, where one XRP (Ripple) had Snoop Dog in attendance. As introductions and connections

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were made, it became evident that the social media channel of choice was either Telegram or Discord, not Twitter or LinkedIn. Further, notable individuals with peer credibility (observed through the significant numbers of attendees at various conference sessions) seemed to disdain LinkedIn (Baldet, n.d.). Even if they had a LinkedIn presence, a person did not declare themselves a blockchain expert. Observing these events made us question the suitability of studying the phenomena of blockchain and what is blockchain from the context of platforms of LinkedIn and Twitter.

Researchers (Fosso Wamba et al., 2020; Remko, 2019) now suggest that supply chain solutions are the next popular blockchain solution (after cryptocurrency). However, significant variances of enactment are evident. Solutions are developed with transactions not placed in blocks, nor validated by all parties within the network, meanwhile still claiming to be blockchain solutions (Natoli & Gramoli, 2016). Additionally, Levy (2018, p. 1) notes that some 85% of blockchain projects will deliver "business value without using a blockchain. This suggests that how blockchain technology is enacted within a specific context also varies and can determine differences in outcomes.

For these two reasons (i.e., **enactment variation** and **contextually based phenomena variation**), one can easily make ill-informed decisions. People with fiduciary obligations will make decisions based on the current discourse and will be challenged due to their bounded rationality and others' opportunism. And sadly, projects and start-ups will continue to fail at an alarming rate costing potential livelihoods, reputations, and foregone business value. The sunk cost associated with project failure is one perspective; another perspective is the triple-bottom-line cost of the social and environmental impacts of blockchain implementation (Song & Aste, 2020; Weber et al., 2017) that may not see a firm organised in the most cost-effective manner (Coase, 1937). Due to the hyperbole surrounding blockchain technology, firms replacing proven solutions with emergent technologies may not fully realise expected benefits due to high switching costs and unproven cost savings.

Several researchers have attempted to create suitability assessment frameworks. Lo, Xu, Chiam & Lu (2017) provide a framework to assess the suitability of projects against the strict definition of blockchain technology. Other assessment models include permissioned blockchain solutions as a potential suitable outcome (Peck, 2017; Wüst & Gervais, 2017).

Current assessment models are limited in two ways. First, the early definition adhered to the technical characteristics of the bitcoin blockchain. The technology has evolved dramatically from the original bitcoin blockchain. For example, the Red Belly Blockchain, built using a democratic Byzantine Fault Tolerance protocol (and other technical differences), offers a throughput of some 400,000 transactions per second compared with the Bitcoin blockchain's throughput of between 2-10 transactions per second. Second, the focus of these assessments is targeted explicitly at matching the problem with the technology, considering the cost-effectiveness of implementing and maintaining such solutions, even if 'suitable'. Based on these variations, a benchmarking tool was created and is presented in this paper.

The motivation for this research comes from this diverse and conflicting discourse that observes an enactment of similar patterns of irrational decision-making to the dot com era (Cooper et al., 2001). We address the stated assumptions (**enactment variation** and **contextually based phenomena variation)** of research to date by presenting first a baseline for what is blockchain (based on how it was originally enacted by Nakamoto). Second, we present how Blockchain solutions are being enacted with industry and by start-up organisations. This paper first presents the current progress of our academic discourse on the topic. We analyse and present these findings highlighting future research opportunities. We also offer a novel benchmarking framework built from an initial iteration of enacted configurations of over 350 blockchain projects and cases highlighted in the literature. The benchmarking framework extends beyond the purest definition of blockchain technology and current assessment frameworks. It shows the variances and the trade-offs for decision-makers, even recommending Application Programming Interfaces (APIs).

The following section discusses the methodology chosen. We outline our systematic literature review and the methods for project selection. We summarise the key literature through a domain and conceptual analysis. We answer, "What is Blockchain Technology?" With Blockchain technology defined, we then expand on the variations of "How it is being enacted?". We present the initial version of the benchmarking tool. We conclude the paper by presenting our research direction, other future research opportunities and conclusions.

2. Methodology

Our research questions about what blockchain is and how blockchain is enacted are answered in two steps. First, a systematic literature review will answer the questions of who, when, where, and what we contribute, as outlined in Figure 1, and summarise the current academic discourse. And second, we review existing blockchain solutions and codify their solution design to determine how blockchain is enacted within specific contexts.

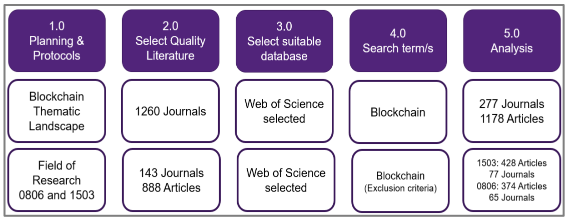

Figure 1. Literature Analysis Methodology

Steps 1 to 5 outline traditional systematic literature review steps (Y. Levy & Ellis, 2006; Okoli & Schabram, 2010). A total of 1260 highly ranked academic journals were selected for bibliometric analysis. The chosen tool was version 3.2.1 (released on 21 Feb 2022) of Bibliometrix/Biblioshiny, an R-developed application. Further details are available in a forthcoming conference publication (Honey et al., n.d.). A summary is provided below.

2.1 Contribution to theory coding

Gregor (2006) presents five ways researchers can contribute to theory. The first is "**Analysis**", – where a researcher establishes foundational knowledge of "What is it?". The second contribution is "**Explanation**", where researchers describe what, why, how, when, and where about the phenomenon of interest. However, there are no testable propositions presented. The third contribution is "**Prediction**", – where testable propositions will be given. These testable propositions may be tested or may only be presented in a research paper of this type. The fourth contribution is "**Explanation and prediction**", – where researchers seek to answer causality. The fifth and unique contribution is "**Design and action research**", – where researchers will try to build prototypes or other artefacts to show how to solve a problem. This contribution type is quite common in computer science. All articles were coded against one of these five contribution constructs.

2.2 Project Selection

An original full dataset (totalling 3283 records) was extracted from Crunchbase on April 2, 2018. A random sample selected 1000 projects for analysis. Further datasets were collected on July 2, 2018, October 8, 2018, January 2, 2019, and April 1, 2019, with a final dataset extracted on November 28, 2020, to determine the survivability of solutions.

Criticisms of Crunchbase are that the information is self-declared and can be out-of-date or erroneous. Each site was, therefore, manually validated during each of these periods. This validation was done in two different ways. After data extraction, a manual website validation was completed for April 2018, July 2018, January 2019, April 2019, and September 2020. Maturity bias was managed through a final website validation using the Wayback Machine – Internet Archive service. Screen captures were taken and compared across each date capture to confirm whether websites changed and aligned with any perception of improving or degrading about being an authentic project. Three hundred fifty projects were viable blockchain solutions, and these projects were used to inform the construction of the benchmarking tool.

3. Literature Review

Steps 1 to 5 of the systematic literature review provide answers to the who, when, where, and high-level analysis of the what. Domain analysis through bibliometric tools allows for a breakdown of who, when, and where. The conceptual analysis provides the analysis of what.

Bibliometric tools allow for a consistent synthesis of the literature. The bibliometric summary highlights 1178 articles across 277 unique journals covering a timespan of publication from 2015 through to early 2022. Three thousand sixty-one authors publish in this area using over 3137 author keywords[1], refined to 1356 keywords plus[2] words. Keywords used by the top 15 authors include bitcoin, blockchain, distributed ledger, supply chain, smart contract, cryptocurrency, security, Ethereum, privacy, sustainability, and the internet of things. Further domain analysis information of who and where researchers publish is available in a forthcoming publication (Honey et al., n.d.).

3.1 Contribution to the theory

The contribution to the theory research framework (Gregor, 2006) was applied to all articles and two specific larger sub-clusters, Business & Management and Information Systems (shown in Figure 2).

[1] Author keywords are words chosen by the author/s to represent their article

[2] Keywords plus are words associated with the document by Clarivate Analytics Web of Science and Scopus databases (Aria & Cuccurullo, 2017)

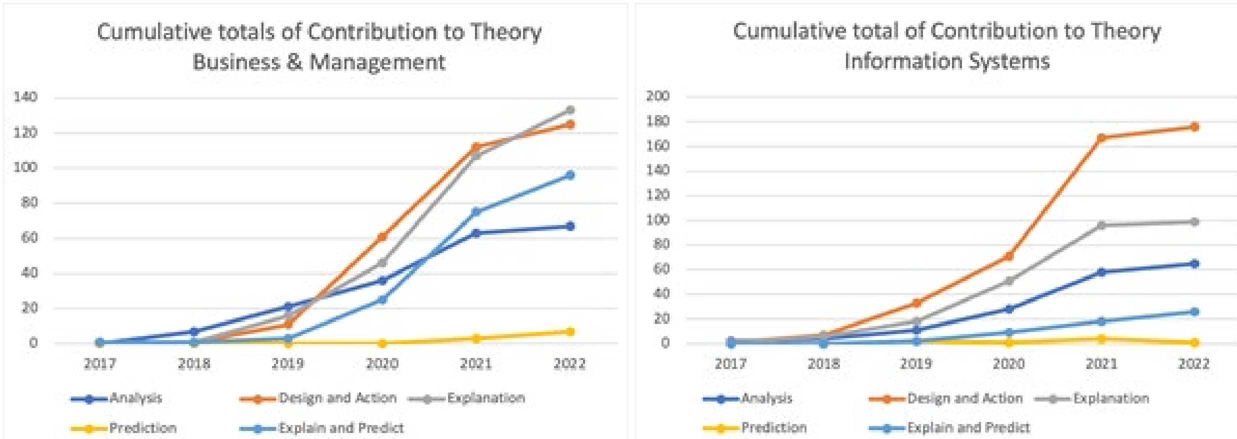

Figure 2. Contribution to theory

3.1.1 Analysis. Analysis research is often viewed as foundational and necessary in early research areas, but researchers are quick to want to offer insights of explanation or explanation and prediction (Gregor, 2006). 2019 shows a change in theoretical contribution for Business & Management researchers (shown in Figure 2 - left). **Analysis** research becomes less prolific as **Design and Action** and **Explanation** research increase exponentially. Information Systems researchers (shown in Figure 2 – right) are producing similar volumes of **analysis** research but are also prolific in creating **Design and Action** Research.

3.1.2 Explanation. Business & Management researchers have contributed over 130 explanation research articles. Comparatively, Information Systems researchers have contributed 100 articles.

3.1.3 Prediction. Neither Business & Management nor Information Systems researchers produce much work on prediction contributions. Researchers' preference appears to be the presentation of explanation and prediction research together. As researchers focus on the following two theoretical contributions, we will also provide a deeper analysis of these areas.

3.1.4 Explanation & Predict. In 2021, **Explanation and Prediction** research is seen to overtake **Analysis** research within Business & Management. This may suggest that these researchers have now set a foundation for blockchain and are presenting testable propositions suitable for theory testing and building theory.

The first **explanation and prediction** article sought theory building, using fuzzy-set Qualitative Comparative Analysis (fsQCA), to identify the "nonmonetary causal factors and informal financial practices [that] play a major role in habits of the financially excluded" (Larios-Hernández, 2017, p. 865).

A more recent paper (Chowdhury et al., 2022) sought to explain and predict blockchain technology adoption within an Operations and Supply Chain management context using a combination of risk management theory (VUCA - volatility, uncertainty, complexity, and ambiguity) and the Technology Acceptance Model (TAM). This study (and many other supply chain studies like it) highlight specific supply chain solutions.

We draw particular attention to Tracr, a solution built for the provenance tracking of diamonds highlighted in the article. Tracr is built on Ethereum through a joint project with BCG Digital Ventures and De Beers; however, it is unknown which version and with which configurations it is built. Reviewing various marketing materials on De Beers' website and other searches resulted in determining that the solution is a permissioned solution, only allowing those authenticated users to join (Sharma, 2018). This variation does not negate the solution satisfying the definition of a blockchain (Yaga et al., 2018). However, a BCG Digital Venture representative said, "it keeps data private and allows participants to selectively share data with only those that they want to." (Sharma, 2018). This solution demonstrates significant variance from the Bitcoin Blockchain architectural design.

3.1.5 Design and Action. There are many design and action research papers (a total of 301 across Business & Management and Information Systems). The research commonly takes one of two paths. Either highlighting weaknesses in the current technology and proposing a way to "fix" the problem or where researchers "test" whether blockchain solutions could be applied to a specific context.

Option 1 is how blockchain technology has evolved. One might suggest that 'Satoshi Nakamoto' is a design and action researcher from academia who released an eight (8) page paper to present their research to solve the double-spend problem (Nakamoto, 2008). Several months later, 'Nakamoto' presented a working prototype. Since then, others have critiqued the solution (Yu et al., 2019), saying what is good and bad about the technology and where it can and cannot be applied.

Option 2 research often presents ways blockchain can be applied within various contexts. Two issues are found with this approach. One, the new prototype technology stack is altered so significantly that it may not adhere to the definition of a blockchain, or two, alternate technologies or non-technical solutions are not considered alongside the blockchain option. For example, the problem in the US of counterfeit checks (or cheques) (Hammi et al., 2021). The banking industry solved the problem of counterfeit checks/cheques in Australia by moving to digital banking. Personal checks/cheques have been phased out completely. Bank checks/cheques still exist for such transactions as car and house settlements where timely assurance of funds is required before handing the title to a high-value property item. In this context, researchers might contest that a blockchain solution may have a specialised role in settlements for high-value items, such as car and house purchases. Still, other options may solve the fake check/cheque issue without blockchain technology.

Another example is the location of electronic vehicle charging stations research (Fu et al., 2020). The research demonstrates solving this problem successfully with blockchain technology. Again, in Australia, the Australian Competition & Consumer Commission (ACCC) monitors fuel prices throughout Australia. Sites like Petrolspy use data gathered by the Commission to offer high accuracy fuel prices to the public. Additionally, Google map queries can help you locate nearby EV charging stations. We contest that a blockchain solution brings no value to what can be solved through a centralised database solution.

As researchers, we must be vigilant and careful regarding what is and what is not blockchain technology. Analysis and Explanation articles are necessary for setting the foundations of research. This research provides an updated (as of 2022) foundation by contributing to analysis and explanation theory by answering our first research question of what blockchain is. In the next section, we present how the discourse about blockchain technology has evolved and defined what blockchain is.

3.3 Conceptual Analysis

The domain analysis has shown what is being researched, highlighting two issues, first, what is blockchain (really), and second, when examining the suitability of the technology, options are not considered. Therefore, this potentially confuses those who need to make technology decisions. Our thematic analysis (Figure 3) across four (4) time slices supports these findings.

Between 2015 and 2018, themes such as future research, blockchain technology and distributed ledger were dominant. 2019 through 2022, there was no further dominance of distributed ledger technology. 2021 sees smart contracts and supply chain research dominate. 2022 has, thus far, seen continued research in supply chain and smart contracts, with new themes emerging in food safety and access control.

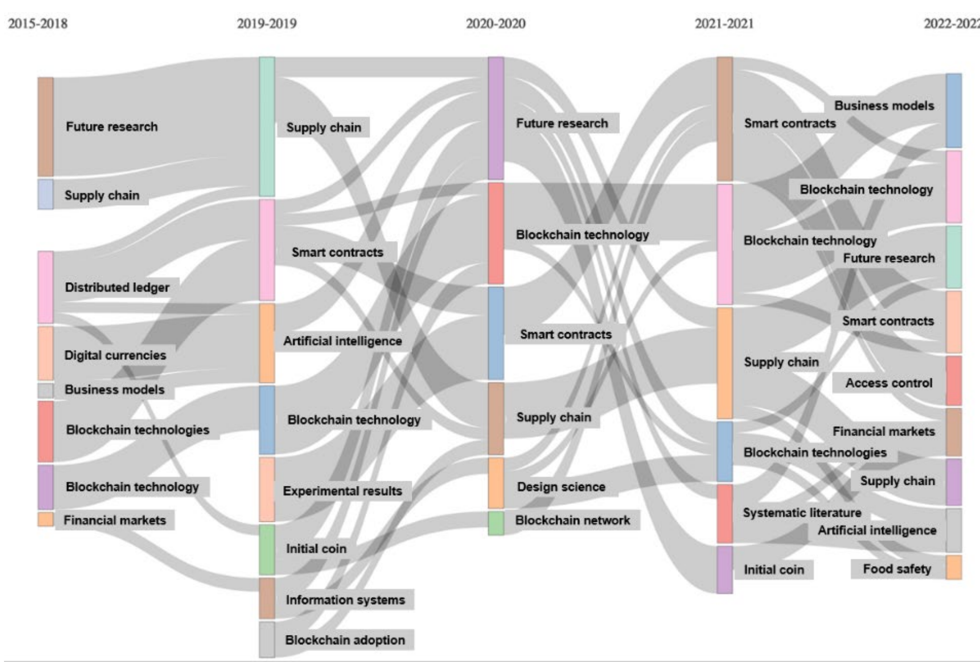

Figure 3. What – Thematic Analysis of Blockchain research

Much of the research has struggled to define blockchain technology (as did the industry), frequently vacillating between the distributed ledger and blockchain terminologies and claiming they were synonyms (Klimos, 2018). However, since 2019 blockchain technology has remained the dominant theme and term used, even though researchers have started to correctly define the difference between blockchain and distributed ledger technology (Pedersen et al., 2019). Further, researchers have begun identifying cases more likely to be called 'blockchain-inspired' (Babich & Hilary, 2020).

3.3.1 Defining Blockchain. A thematic literature analysis highlighted that academic research remains in its preliminary stages and has not yet formally stated, 'What is blockchain?'. Due to the rapid rate of change within the technology stack, seeking to define 'What is blockchain?' necessitates considering non-traditional yet reputable outlets, such as NIST, to help solidify blockchain's definition. The basis of this research is based on the following definition:

> *Blockchains are **distributed digital ledgers** of **cryptographically signed transactions** that are **grouped into blocks**. Each block is **cryptographically linked** to the previous one (making it **tamper evident**) after validation and undergoing a **consensus decision**. As new blocks are added, older blocks become more difficult to modify (creating **tamper resistance**). New blocks are **replicated** across copies of the ledger within the network, and any conflicts are resolved automatically using **established rules.*** (Yaga et al. 2018, p.1, emphasis added)

A benchmarking tool capturing the technical continuums of the technology stack is presented below (see Figure 4). The tool starts the continuum with the Bitcoin Blockchain architecture and then steps through various technology architecture choices (and the associated trade-offs) along a continuum to end with distributed data (often achieved through Application Programming Interfaces – APIs). This tool also provides questions to help a decision maker choose various options based on their specific business context. For example, one company may be the start of the supply chain, know their buyers intimately, and already have well-drafted legal contracts in place. As such, this company may opt for a permissioned solution as trust between parties is already well established through these contracts. The cost to switch to solve this using blockchain technology would not deliver the required business value.

For a specific example of this in action, R3 formed a consortium of organisations (primarily companies from the financial sector) to investigate blockchain technology and subsequently created Corda). Corda transactions are only shared between the sender and receiver and are not transferred, validated, or stored by every network node. Such technical deviations away from the original blockchain architecture have given rise, and increased use, to the term 'distributed ledger technology' or DLT to encapsulate this broader group of systems (e.g., Hyperledger Fabric). However, comparing the technical architecture of Corda to the benchmarking tool below, it may fit within a broader category again of a distributed system, where it is potentially very close to just looking like encrypted APIs.

3.3.2 Benchmarking tool development. The benchmarking tool proposes a six-tier continuum. The reality is that the technical options available within the technology stack are far more expansive (Rauchs et al., 2018). However, the variations observed with an initial dataset of 350 blockchain projects suggest the above to be a potential parsimonious model. This benchmarking tool is yet to be tested as a predictive tool but currently provides a deductive presentation of the blockchain technology continuum.

Each level is differentiated with certain technical features. It commences first with the purest form of the Bitcoin Blockchain. The solution is permissionless, open to all, with unknown actors transacting in a malicious environment, and the transactions are digital. The next level is not significantly different. It introduces the capability of event-driven autonomous code. Bitcoin Blockchain can, in a minimal capacity, perform event-driven commands. However, Ethereum offers robust event-driven autonomous code structures with the Solidity programming language.

The levels continue to change depending on crucial business requirements. Timeliness and throughput requirements of transactions mean that a distributed ledger solution may be better suited rather than a blockchain solution. Changing consensus methods can significantly reduce the time to commit a transaction. Additionally, this will also reduce the cost of running the system.

Next, trust becomes a factor. Can trust be created algorithmically, or is it more cost-effective to create trust by being known to one another with proven legal contracts between the parties? Many supply chains already have contracts, so that switching costs may be too high. Additionally, many buyer/seller contract relationships may have built significant goodwill over many years of trading already, making the cost of switching unnecessary.

Figure 4. Benchmarking tool

Next is transparency. Corda was developed to ensure the privacy and security of transactions. It is suggested that this solution does not comply with the definition of a distributed ledger. It may be best to call it a distributed system rather than a blockchain. When you only transmit a very restricted data set, a decision-maker may find it more cost-effective to implement application programming interfaces (APIs) or portal services offered through systems such as MS Dynamics.

4. Further Research

We have heeded the call of Risius and Spohrer (2017, p. 404) to continue the research in specific areas of blockchain technology, specifically their recommendation for research looking at "trade-offs between different blockchain features". There are ample gaps in the blockchain research landscape. Finding the novel space that adds value, provides a unique contribution to theory and practice, and at the right time is certainly more challenging.

In this paper, we have answered "What is Blockchain?" as of 2022. This paper has presented the current progress of our academic discourse on the topic. As this research began, it was never the intention to problematise the research (Alvesson & Sandberg, 2011), feeling there were plenty of research opportunities. However, research must build from firm foundations. To address the initial assumptions (e.g., **enactment variation** and **contextually based phenomena variation**) we have answered what blockchain is, as well as what blockchain is not.

Second, we have presented a novel benchmarking tool that summarises how blockchain technology is being enacted, demonstrating that researchers are calling some solutions blockchain when other definitions are available and are more suitable. The novel benchmarking framework is built from an initial iteration of enacted configurations of over 350 blockchain projects and cases highlighted in the literature. The benchmarking framework extends beyond the purest definition of blockchain technology and current assessment frameworks and shows the variances and the trade-offs that decision-makers can make.

We also call on researchers to represent use cases using this new continuum benchmarking tool rather than calling everything a blockchain solution. We also encourage further research comparing the costs of these trade-offs. Many businesses will make project decisions based on return on investment, bringing switching and transaction costs together. For example, the cost of drafting legal contracts between two parties may still be more cost-effective than building an open and permissionless smart contract on Ethereum.

Our next steps with our research will continue to analyse the enactment and survivability of the 350 solutions. The literature review suggests a strong interest in supply chain solutions. We are keen to confirm whether this aligns with how the solutions are being enacted within the industry. FinTech, RegTech, and AgTech hint at other areas of interest for which the industry is keen to explore and build blockchain solutions, yet research in regulation and agriculture remains limited. Researchers currently, and rather obviously, still seem interested in predicting the price of Bitcoin or initial coin offerings (Cretarola & Figà-Talamanca, 2019).

5. Conclusion

Following Risius and Spohrer (2017), we have looked specifically at what blockchain is, but have also defined what blockchain is not. We have also presented a novel benchmarking tool to allow other researchers to assess solutions and group them for more appropriate comparisons and suitability determination.

We have presented a summary of blockchain research. We have also defined what constitutes a blockchain. Informed by these findings, we recommend a challenge to researchers to confirm solutions claiming to be blockchain solutions using the benchmarking tool before declaring positive (or negative) use cases.

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