Journal Pre-proof

Distributed Ledger Technology: Its Evolutionary Path and the Road Ahead

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PII: S0378-7206(20)30249-4

DOI: https://doi.org/10.1016/j.im.2020.103316

Reference: INFMAN 103316

To appear in: *Information & Management*

Received Date: 5 December 2018

Revised Date: 3 March 2020

Accepted Date: 17 March 2020

Please cite this article as: Perdana A, Robb A, Balachandran V, Rohde F, Distributed Ledger Technology: Its Evolutionary Path and the Road Ahead, *Information and amp; Management* (2020), doi: https://doi.org/10.1016/j.im.2020.103316

Distributed Ledger Technology: Its Evolutionary Path and the Road Ahead

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Highlights

- Our study used organizing visions to comprehend media influences on DLT diffusion.
- We described the critical features of DLT diffusion and its impact on future research.
- The popular news media led the way in helping the public better understand DLT, including its shortcomings and potential benefits.

- We found that the interpretation stage of DLT diffusion was characterized by competing arguments.
- The news media has assisted DLT dissemination while governments, organizations, and investors have validated its development.

ABSTRACT

Various arguments for and against distributed ledger technology (DLT) appear in the media. By analyzing DLT-related online English news articles from 2010 to 2018, first, we use organizing visions to investigate DLT's history of evolving and expanding. Second, following the Gartner hype cycle stages, we observe how DLT may offer ripe opportunities for future inquiry. We found DLT's diffusion was characterized by competing arguments. While DLT was initially viewed as somewhat questionable, communities collectively have (re)interpreted it favorably. DLT provides researchers with opportunities warranting further development in the information systems field.

Keywords: Distributed ledger technology, blockchain, organizing vision, technological diffusion; text analysis.

I. INTRODUCTION

In Distributed Ledger Technology's (DLT) infancy, the technology was commonly referred to as Bitcoin, largely because it was associated with Bitcoin cryptocurrency [1]. Bitcoin caught the imagination of many as the first widespread application of a virtual currency [2]. Although the terms, Blockchain and DLT, have been used interchangeably in both research and the media, DLT appears to be gaining favor in research with Blockchain preferred by the media [3–5]. DLT is a unified term for the broader technology, whereas, Blockchain refers to a particular application [6–9]. Given the various arguments for and against DLT, implementing and adopting it can potentially increase our understanding about its diffusion.

The popular news media continues its wide coverage of the numerous perspectives and agendas of DLT or Blockchain, including their applications. Some governments (e.g., USA, UK, and Canada) and their regulatory bodies have sought to appropriately guide the use of DLT. Furthermore, substantial amounts of venture capital are being invested in DLT for implementing financial services [10]. Given DLT's current path, investigating its diffusion could guide future research to better understand and solve issues surrounding DLT adoption and implementation. Therefore, we pose the following research question: *How have Bitcoin, Blockchain, and DLT been interpreted, legitimized, and mobilized since its inception?* and the proposition, *DLT diffusion follows the Gartner hype cycle.*

To address these questions, we collected a sample of 5,698 (3,911,229 words) English language electronic news articles transmitted from 2010 to 2018. We analyze them using automated machine learning for text analytics to explore DLT diffusion and related topics, and use organizing visions to understand the matters emerging from the diffusion [11]. We found that the interpretation stage of DLT diffusion was characterized by competing arguments. While DLT was initially viewed as somewhat questionable, communities collectively have (re)interpreted it favorably. By increasing public awareness of DLT, the news media has assisted its dissemination, while governments, organizations, and investors have validated its development.

Following the annual Gartner hype cycles of emerging technologies over eight years (2010–2018), we compare DLT-related publication hype in the media with these hype cycles and propose how future research might proceed [12–14]. We identify three potential research areas, namely, DLT design, adoption, implementation, and use cases; the impact of DLT on individual users and organizations; and the broader DLT ecosystem. Additionally, our results might explain the progress of DLT and how future applications' development might be restricted.

This article is organized as follows. Section II describes the development of DLT, its technological diffusion in the media, and concludes by formulating research questions. Section III describes our methodology, Section IV presents our findings, with Section V explaining how they contribute to the literature, and what future research is relevant. The conclusion summarizes the limitations of our research and presents our final words.

II. BACKGROUND, THEORY, AND RESEARCH QUESTIONS

The Development of Distributed Ledger Technology

The notorious Bitcoin[1] article written by Satoshi Nakamoto as the initial application of DLT has been widely circulated [15]. Bitcoin is a particular instantiation of Blockchain. While the terms Blockchain and DLT have been used interchangeably, DLT is more complete [7,8]. DLT originates from distributed authentication with the support of advanced cryptographic proof. DLT maintains its data in blocks and continuously adds new sequential blocks of data [16], which are simultaneously distributed and synchronized among the participating nodes in particular networks. It refers to higher-level innovation or technology used to resolve problems related to shared and controlled data, and to securely manage multiple transactions by many organizations [6,10,17]. Furthermore, governments and their regulatory bodies appear to favor DLT over Blockchain [18–20]. Therefore, we use the term DLT in this paper.

1 Cryptocurrencies existed prior to Nakamoto's Bitcoin; however, Nakamoto was the first to resolve the "double spend" problem.

While Bitcoin remains controversial, DLT continues to evolve. Over time, governments, technologists, technopreneurs, professionals, and academics have become more interested in DLT than Bitcoin [19]. DLT can be implemented in permissioned or permissionless variants [3]. Permissioned DLT permits authorized users to contribute to private DLT networks by adding and validating transaction blocks, whereas permissionless DLT permits anyone to participate in public DLT networks. These two variants have different mechanisms in their security, algorithms, and privacy. Governments and financial institutions appear primarily interested in permissioned DLT [4,21–23], e.g., applying permissioned DLT can increase the efficiency of financial and security settlements and expedite financial clearing by eliminating financial intermediaries in the settlement and clearing processes. DLT may also facilitate more timely, verifiable, and precise accounting and auditing [24,25]. In contrast, the most prominent applications of permissionless DLT are Bitcoin and Ethereum.

Information Technology (IT) Diffusion in Media

The IT diffusion literature covers Information Systems, communication, sociology, and social psychology. Since the 1990s, IT diffusion has attracted IS researchers who explain diffusion from both institutionalism and economic rationality perspectives [26,27]. IT diffusion research also recognizes the role of individuals and organizations in the wider community and describes not only the stages of diffusion, but also their content [11,28–30].

IT diffusion research provides insight into the characteristics of adopters (e.g., skills, knowledge, and psychological perspectives) and the specifications of the diffused and adopted IT (e.g., its physical characteristics) [28]. This prior research nonetheless tends to place little emphasis on the social discourse about and the media roles involved in diffusing technology [11,28], even though they could influence the success or efficiency of diffusing IT. Researchers note the following four aspects are critical in IT diffusion: learning and discourse, product reviews, public framing, and the polarity of technology discourses [28,30,31].

IT diffusion is increasingly sophisticated, not just because of the advancement of technology, but also the multiplicity of channels conveying information related to the technology [32]. Diffusion of new IT is complex involving many and conflicting forms of communication among multiple interested parties. During diffusion, those interested in an innovation engage in language that rhetorically constructs a coherent goal for the innovation [11,28,33]. In short, media and interpersonal communication of information related to new technology can substantially influence IT adoption [34].

Digital media and communications and journalists are commonly involved in IT diffusion [32,35]. The former creates interconnections and rapid access to information. Those involved in creating and disseminating news influence information flows and content. Across the years, journalists and the media

have played a significant public role in disseminating and interpreting information about new technology [32]. The widespread adoption of microcomputers arose because journalists promoted their efficacy while the media devoted columns to IT [33,36]. In the mid-1990s, German news media helped promote the Internet positively [37], and *Time* magazine emphasized the Internet's ability to facilitate business activities and enhance individual freedom and intelligence [38].

DLT is following a similar diffusion by maintaining a high profile in the media. Prior to its use as the preferred term for the technology, Bitcoin also had a high media profile. However, it suffered, and possibly still does from negative public perception arising from its use in speculative investment and application in dubious transactions, notably those involving *Silk Road* [2]. Competing public discourse nonetheless has helped the technology behind Bitcoin to flourish and promote new applications of DLT. Media coverage has also likely helped shift public attention from Bitcoin to DLT.

Research Questions

We argue that DLT is innovative IT. Three important attributes of innovation are: its being new, and motivating improvement and change [39]; it brings new ideas, services, practices, designs, and technology; or products that improve individuals, organizations, and society [34]. More specifically, we refer to IT as a product of engineering design used in society for practical ends, potentially generating particular social impacts [40]. Because DLT is an emerging technology, we contend that it can transform future practice and research. Technologists, practitioners, and academics propose a diverse array of applications for DLT: using it for trade execution settlements, asset exchanges, physical asset registrations, supply chain management, cash reserve management, smart contracts, and algorithmic regulations [41]. Like other new technology, DLT must negotiate being diffused before becoming mainstream and developed.

The diffusion of technology has been widely investigated using the diffusion of innovation (DOI) and institutional theories [42–44]. DOI refers to the flow of knowledge in five stages: after the idea's exposure comes its persuasion, decision, implementation, and confirmation [34]. DOI, however, provides scant information about the extent to which IT is adopted and implemented in the community or organizations. Swanson & Ramiller [11], focusing on content and the community's involvement with that information suggest that IT is diffused through communities of shared interests and convergent views. These diverging views suggest that organizing, shaping, and understanding new technologies is not a uniform process [11].

Past research on institutional theory suggests that innovation starts from rational choice and later innovation becomes institutionalized and "taken for granted" [45]. Innovation or new rationalities may diffuse, however, with competing ideas from multiple actors compounded by politics, social learning, and contextual factors [45,46]. The diffusion of technology, therefore, is a dynamic process. Swanson & Ramiller [11] provided a lens for incorporating the institutional process in technology diffusion. They

suggest that technological diffusion and the institutional process can be better comprehended by understanding organizing visions that reflect how actors and communities dynamically shape their consensus while pursuing shared visions of particular IT innovations [30]. Organizing visions theory helps us to understand how those (actors & communities) involved in diffusion socially conceive and construct IT, and how ideas about new technology are rationalized, adopted, and implemented. Organizing visions involves three aspects: interpretation, legitimation, and mobilization [11] and can help organizations build guidelines for those adopting IT and also permit experimentation with the technology [30]. Guided by organizing visions theory, we analyze the media content involved in new technology diffusion. This analysis helps us to capture public perspectives, discourses, and issues surrounding DLT development. Therefore, we offer the following research question:

RQ: How have Bitcoin, Blockchain, and DLT been interpreted, legitimized, and mobilized since its inception?

While organizing visions may be useful for comprehending the language surrounding IT diffusion and the *know-what*, *know-how*, and *know-why* of adopting IT, it cannot explain the lifecycle of technology as it relates to the eventual position of emerging technologies in the market [12]. The Gartner hype cycle is widely used by industry to determine the status of technologies, when best to adopt them, and how to strategically decide about particular technologies. The Gartner hype cycle consists of five stages of technology's progression (technology trigger, the peak of inflated expectations, the trough of disillusion, the slope of enlightenment, and the plateau of productivity, and improves the understanding of new technology's eventual status) [12,13].

Industry has used the Gartner hype cycle for some 20 years [12,13]. While Gartner's hype cycle is undoubtedly industry-focused, several leading journals in the technology and management and accounting information systems disciplines look to the hype cycle to identify both the emergence of new technologies and future research opportunities (e.g., [13,14,47,48]). In accounting research, the strategic and emerging technology stream uses the Gartner hype cycle to identify strategic issues and research. Typically, researchers are interested in investigating the technology when it is at the peak of inflated expectations. In addition, we presume that DLT diffusion follows the Gartner hype cycle. The cycle's ability to capture IT's progression is helpful in moving forward practice and research in the IT field. Furthermore, O'Leary [14] suggests it can help identify different research approaches for particular technologies. Following the stages of the Gartner hype cycle, we attempt to map future research in IS involving DLT, which leads us to the following proposition:

P: DLT diffusion follows the Gartner hype cycle

The research question and the proposition are concerned with DLT and how the media influences its diffusion and impact on research. The following provides our rationale behind the sample data and research method.

III. RESEARCH CONTEXT, SAMPLE DATA, AND RESEARCH METHOD

Research Context

News plays an important role in diffusing new technologies (e.g., [32,33,36,49]) because it introduces technologies to the public and raises the public's awareness, induces people to discuss technologies, and can help technology adoption decisions [32,33]. We observed that online news, in particular, has performed this role for DLT. The first news article featuring Bitcoin in 2010 gave it a profile that has since remained high, particularly when it was associated with illegal activities. This attention to Bitcoin likely stimulated interest by governments and organizations into its enabling technology. Motivated by this news-diffusion relationship, we are interested in further exploring DLT's diffusion-related content, and thus select online news media as the sample for our research.

Sample Data

We selected English language news articles in electronic media covering the period from 2010 to 2018 and used the search terms, "Blockchain," "Bitcoin," and "Distributed Ledger Technology." We used these three terms as Bitcoin was the first widespread application of Blockchain, subsequently Blockchain and DLT are often used interchangeably. We used the LexisNexis database to collect our sample data, as it permits searching for the most relevant news within the search period. We noted that from 2010 to 2011, little was published on Bitcoin, Blockchain, or DLT although the number of articles increased between 2012 and 2018. To make our search representative and manageable, we collected articles within the periods, 2010–2011, 2012, 2013, 2014, 2015, 2016, 2017, and 2018. For each year other than 2010–2011, we collected 1,000 samples based on the first 1,000 results provided by LexisNexis and sorted them by relevance. Table 1 presents our sample data.

Table 1. Sample data of newspaper titles from 2010 to 2018

Year Group	Search results	Samples collected	Articles discarded due to irrelevancy, or fully/partially duplicated	Final Samples
2010-11	97	97	13	84
2012	129	129	28	101

Year Group	Search results	Samples collected	Articles discarded due to irrelevancy, or fully/partially duplicated	Final Samples
2013	> 1,000	1,000	66	934
2014	> 1,000	1,000	184	816
2015	> 1,000	1,000	196	804
2016	> 1,000	1,000	21	979
2017	> 1,000	1,000	17	983
2018	> 1,000	1,000	3	997
Total Final Samples				**5,698**

Any articles duplicating the same news and irrelevant news articles, such as advertorials and event invitations, were discarded leaving us with, 5,698 distinct titles.[2] Our sample of 5,698 articles provided a corpus of 3,911,229 words. The articles were classified by publication year as indicated in the preceding paragraph and analyzed using Leximancer textual analytics software.

Research Method

Leximancer is suitable for exploratory and predictive textual analysis without researcher-driven coding; thus minimizing researcher subjectivity and is also useful for analyzing large quantities of textual data that would otherwise be time-consuming [50]. Its advantages are evident for content, thematic, discourse, and sentiment analyses (e.g., [31,51–53]).

Leximancer visually displays the extracted information, using a conceptual map that presents a "bird's eye view" of the concepts contained within the text. On the map, the size of the concepts relates to their frequency of occurrence and their proximity relates to their co-occurrence with other concepts. A theme with a larger font represents a group or cluster of concepts that have some commonalities or connectedness as evident from their close proximity to the concepts with a smaller font. The most frequent concepts appearing in each cluster or group will form themes [54]. Leximancer allows users to validly infer the ideas contained within the text, properties of the writer or speaker, the audience to which the material is presented, or properties of the culture of the time in which the material was written [54,55].

Our text analysis consisted of two steps. Step 1 involved data cleaning, sorting, and organizing in word processing documents. Data cleaning, for example, involves removing coarse data, such as irrelevant symbols appearing in articles. We then sorted the data according to their publication year and removed

[2] The full list of articles is available on request from the authors.

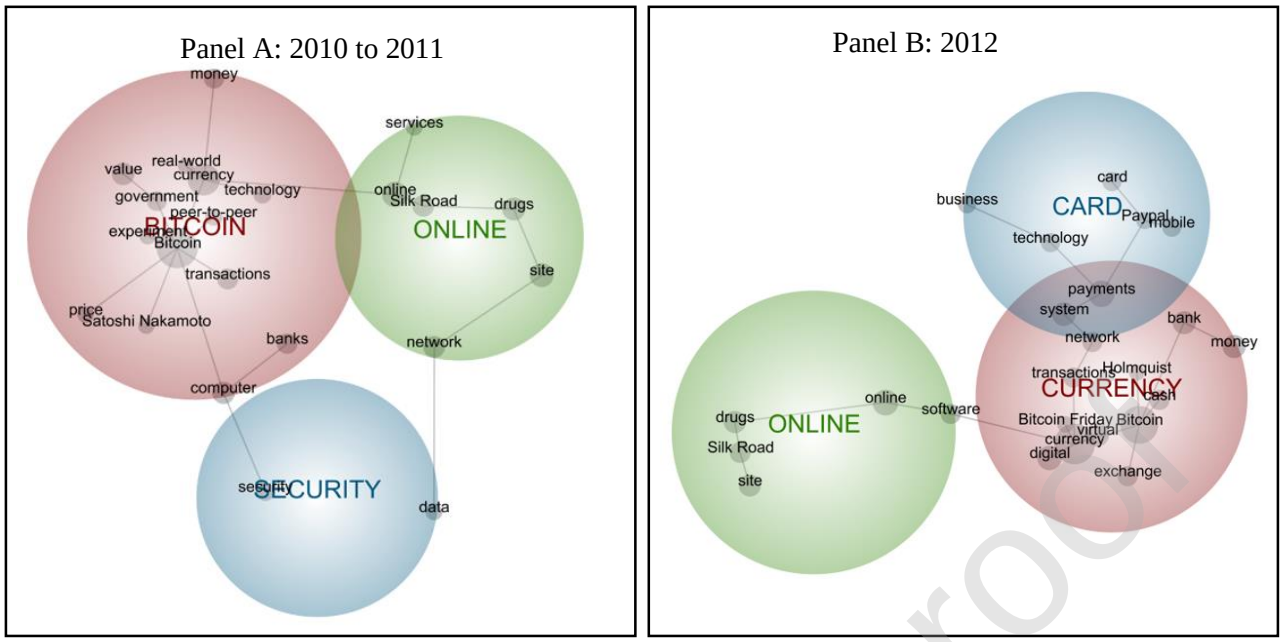
irrelevant headers (i.e., authors and publishers' names) and footers in the articles (i.e., LexisNexis database information). Step 2 involved populating Leximancer with our year-classified data to reveal their patterns. To avoid irrelevant concepts in our analyses, we discarded words having weak semantics (i.e., stop words and nonessential words). While Leximancer is considered more reliable than researcher-driven coding analyses, its reliability can be enhanced by performing multiple analysis iterations to identify their consistency [31]. We did such iterations by investigating both broader and narrower themes. To help increase the reliability of the analyses, in the concept maps we included only the most frequent and relevant words appearing in the dataset. We limit the number of themes (i.e., three to five themes) to aid comprehension of the map and to make the analysis more straightforward. The words' relevance to DLT diffusion was determined by scrutinizing the text excerpts from the Leximancer textual dataset.

IV. FINDINGS

DLT themes in the period from 2010 to 2011

To describe how DLT has evolved from 2010 to 2018, we outline the dominant concepts and themes for each year to 2018, beginning with 2010-2011 (see Figure 1 Panel A). During 2010-2011, the largest theme was *Bitcoin*. Both *online* and *security* themes had relatively similar sizes. The news media did not feature DLT and/or Blockchain as a concept or as a theme in this map, because in 2010 this technology was still in its infancy. The concepts appearing under the theme *Bitcoin* (e.g., Satoshi Nakamoto, experiment, currency, and peer-to-peer) suggest that the media is beginning to inform the public about Bitcoin. Bitcoin began to diffuse from 2010 to 2011, largely because it was often associated with questionable transactions. Two important features of Bitcoin: security and pseudoanonymity, brought both favorable and unfavorable commentary. The themes *online* and *security* in the concept map illustrate media's focus. (See appendix for the relevant media excerpts of DLT themes each year).

Figure 1. DLT Themes from 2010 to 2012



DLT themes in 2012

In 2012, three themes appear in the second concept map (see Figure 1 Panel B): *online*, *currency*, and *card*. The theme sizes are, again, largely similar. In 2012, B*itcoin* appeared as a concept not as a theme. The presence of *currency* as a theme indicates that the number of text blocks containing *currency* was greater than the other *concepts* in the *currency* theme. Concepts appearing in the *online* theme remain the same as those from 2010 to 2011. Media attention continued to focus on Bitcoin and its association with *Silk Road*. Bitcoin was perceived as a shadowy currency associated with the dark web.

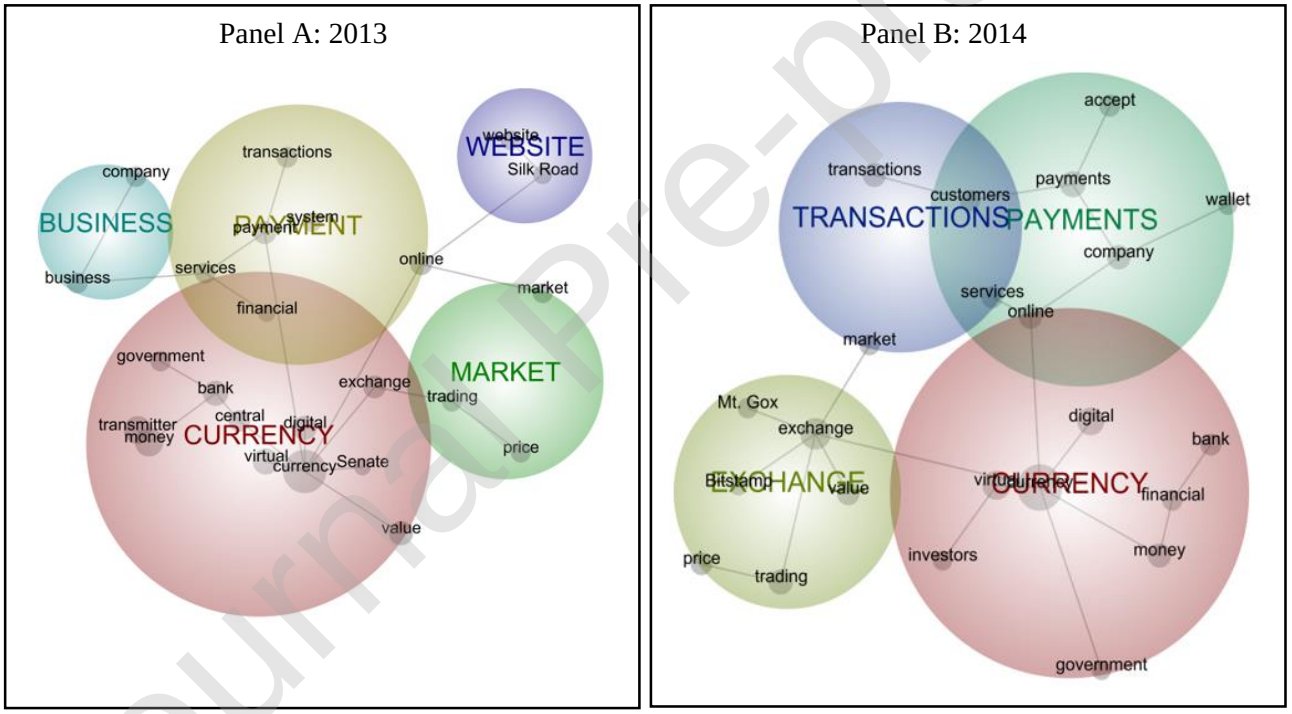
During 2012, media also covered Bitcoin's positive attributes, e.g., in the *currency* theme were the concepts *virtual* and *exchange* perhaps alluding to Blockchain's role in enabling cryptocurrencies. Apart from the above concepts, *Holmquist* and *(Bitcoin) Black Friday*[3] surprisingly appeared as concepts in the *currency* theme. These two concepts likely reflect an early initiative to raise awareness of the potential, positive uses of Bitcoin. The c*urrency* theme intersects with the *card* theme suggesting that the themes' concepts revolve around the potential of Bitcoin to be expanded to accommodate expediting payments and transactions between customers and merchants through mobile devices.

[3] Jon Holmquist initiated *Black Friday* as an event for Bitcoin enthusiasts and merchants to actively promote the use of Bitcoin.

DLT themes in 2013

The major themes in 2013 are *currency* and *payment* (Figure 2 Panel A). Concepts appearing in the *currency* theme are largely similar to those appearing in 2012 except for *senate* and *transmitter*. These two concepts indicate that policy makers in the USA started to take an active interest in Bitcoin, and that regulations were being formulated to minimize the uncertainty and risks associated with Bitcoin transactions. *Currency* co-occurs more with *payment*, suggesting that people, merchants, and transactions are linked. Initiatives related to using Bitcoin for mobile payment transactions began to be implemented by certain companies and startups. Following these initiatives, governments were concerned with the regulation of such transactions.

Figure 2. DLT Themes 2013 to 2014



Market is present in the concept map intersecting with *currency*, suggesting that cryptocurrencies like Bitcoin are gaining popularity as a medium of exchange. Online exchange markets began to facilitate Bitcoin trading, however, its value fluctuated widely. Two smaller themes in the concept map were *website*

and *business.* While present, they remain somewhat distant, perhaps indicating awareness, but not certainty about their role. *Silk Road* continued to appear as a concept in the *website*. Again, this may result from its high (residual) news profile. During 2013, media widely reported the termination of *Silk Road* by the FBI. Despite negative stories related to Bitcoin, multiple companies, organizations, and startups considered and began to adopt and use Bitcoin.

DLT themes in 2014

Figure 2 Panel B, presents the concept map for 2014 with *currency* and *payment* remaining the two dominant themes. The other two themes with relatively similar importance were *transactions* and *exchange*. All concepts appearing in the currency theme remained the same as the previous concept maps from 2010 to 2013 except *investors*. Some companies and startups had raised substantial amounts of funding from investors and venture capitalists suggesting that Bitcoin is starting to garner attention from investors. Many of the articles in 2014 reflected the supporting and opposing arguments that Bitcoin induces. The *payments* theme seems to have cemented the links between the *currency* and *transactions* themes suggesting that *Bitcoin* grew as a medium of payment in 2014.

The theme *exchange* is now a little distant from the other three themes. The concepts under this theme provide hints at one of the critical events in Bitcoin's history. Until 2014, *Mt Gox* was the leading Bitcoin exchange. In 2014, *Mt Gox* filed for bankruptcy and the matter was still before the Japanese court in 2019. Mark Karpelès, former CEO has been found guilty because of data manipulation. The case of *Mt Gox* generated unfavorable stories for Bitcoin particularly because it was often associated with *Silk Road* in the popular press.

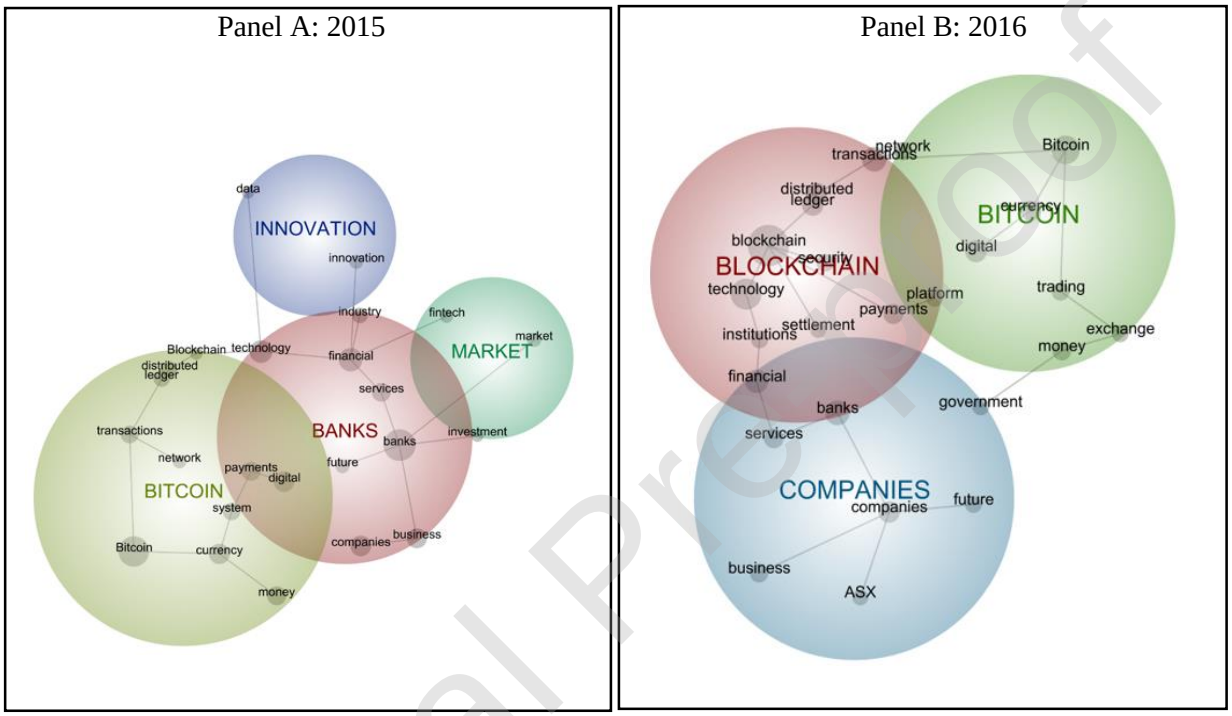
DLT themes in 2015

The 2015 concept map showed the reemergence of the theme *Bitcoin* and also greater co-occurrence between themes than the other concept maps (see Figure 3 Panel A) with *banks* co-occurring with *Bitcoin, innovation,* and *markets*. The 2015 map also found new theme and concept configurations (e.g., *Bitcoin* contained concepts such as *Blockchain* and *distributed ledger*). These two concepts likely indicate that the shift in terminology from *Bitcoin* to *Blockchain* to *distributed ledger* is underway.

Other new concepts appearing on the 2015 map were *innovation, future,* and *fintech*. In 2015, the media appears to advocate the broader solutions provided by Blockchain and DLT, shifting the focus of their articles toward advocating DLT solution perspectives indicating an increasingly forward-looking view of DLT capabilities. Overall, the concepts suggest that DLT is starting to solidify, that users are beginning to see potential services and applications for the technology, and that there is potential for investments in the technology. In other words, DLT is no longer the domain of, perhaps, questionable dealings through

Bitcoin; rather it is becoming a viable technology that is capable of disrupting traditional services and transactions.

Figure 3. DLT Themes from 2015 to 2016



DLT themes in 2016

In 2016, the Leximancer concept map (see Figure 3 Panel B) shows the closer occurrence of *Blockchain* with the other themes: *Bitcoin* and *companies*. For the first time, *Blockchain* is a theme on the map thus suggesting that Blockchain was then viewed as one of the potential technologies to disrupt businesses. Present in the Blockchain theme are the new concepts: *platform*, *settlements*, and *institutions*. We speculate these concepts indicate a growing recognition that Blockchain technology will be at the forefront of significant change in how businesses and markets operate. Blockchain, for example, helps enable smart contracts permitting trusted agreements and transactions to be made between multiple anonymous parties without the need or reliance on a central authority. In the *companies* theme, the concepts *future* and *ASX* appear. *Future* perhaps signaling the broadening of Blockchain's applications to nonfinance companies. Some companies, for example, were experimenting with DLT for solutions such as smart contracts,

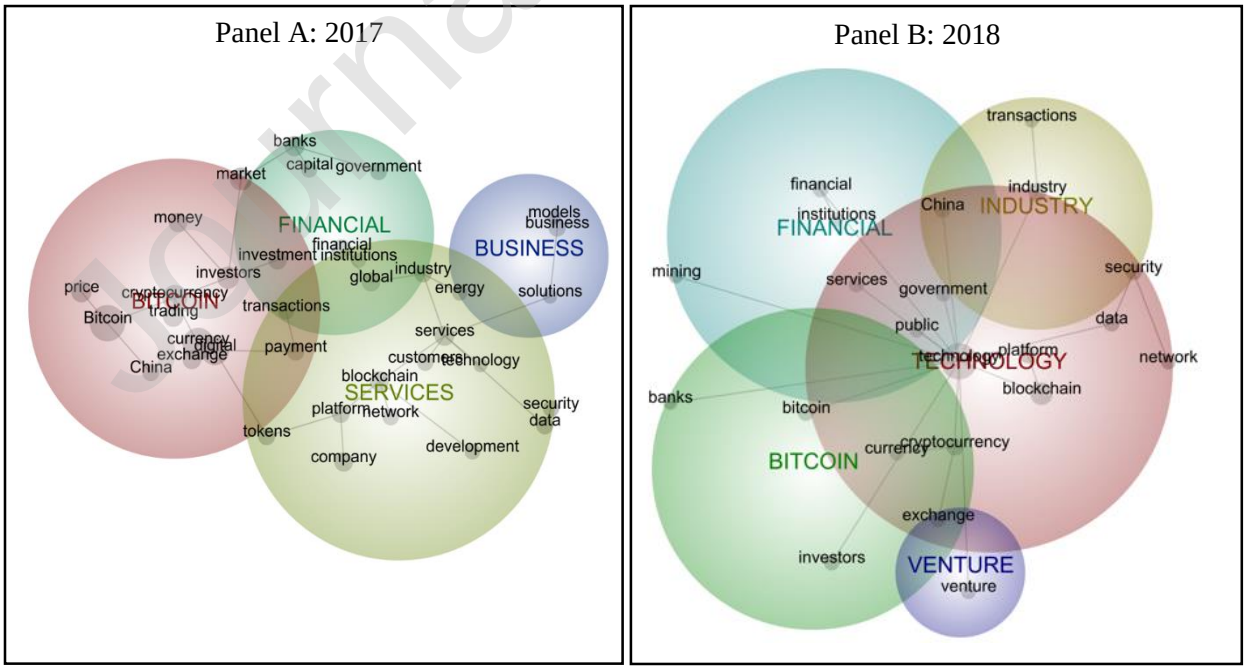
electronic health records, and digital cash settlement systems. Further, the emergence of *ASX* as a concept suggests that the companies listed were starting to explore and experiment with DLT.

DLT themes in 2017

Figure 4 Panel A presents the Leximancer map for 2017 with *Bitcoin* and *services* as the two central themes. The other two themes were *financial* and *business*. Blockchain disappeared as the theme and was replaced by service. Blockchain, however, remains central in the service theme connected with other concepts such as, *platform*, *network*, and *services*. The service theme may imply the greater applicability of Blockchain to provide service innovation. Blockchain technologies are increasingly popular as they decentralize data, remove intermediaries, automate transactions, and secure online payments. Companies are also experimenting with Blockchain use in the energy, property, healthcare, and global trade and shipment sectors.

The concepts under the *Bitcoin* theme are largely similar to those appearing in previous years. Concepts like *digital*, *currency*, *trading*, *money*, *transaction*, and *exchange* are among the most frequently recurring concepts. A new concept appearing in the theme was China. China's appearance as a concept may arise due to the prevalence of Bitcoin farms and their reliance on accessible and low-cost energy. This appearance may also reflect China's ban on the creation and sale of new cryptocurrencies. The ban may be a result of concerns related to financial and social stability centering on cryptocurrencies, particularly, Bitcoin and its price volatility. As a consequence, China's government had ordered the closure of the country's major cryptocurrency exchanges.

Figure 4. DLT Themes from 2017 to 2018



Financial appeared as the third major theme containing concepts like *banks*, *capital*, *government*, *financial*, *institutions*, *global*, *investment*, and *transactions*. These concepts seem to confirm that financial institutions are becoming more confident in Blockchain use. Blockchain has the potential to help simplify financial intricacies leading to more efficient processes, for example, automating financial settlement processes, easing paperwork, and data sharing. Business reemerged as a topic in 2017. While in 2013 the business theme referred to the early adoption of Bitcoin from companies and startups, in 2017 the business theme was associated with Blockchain as the enabler for creating new business model and solutions.

DLT themes in 2018

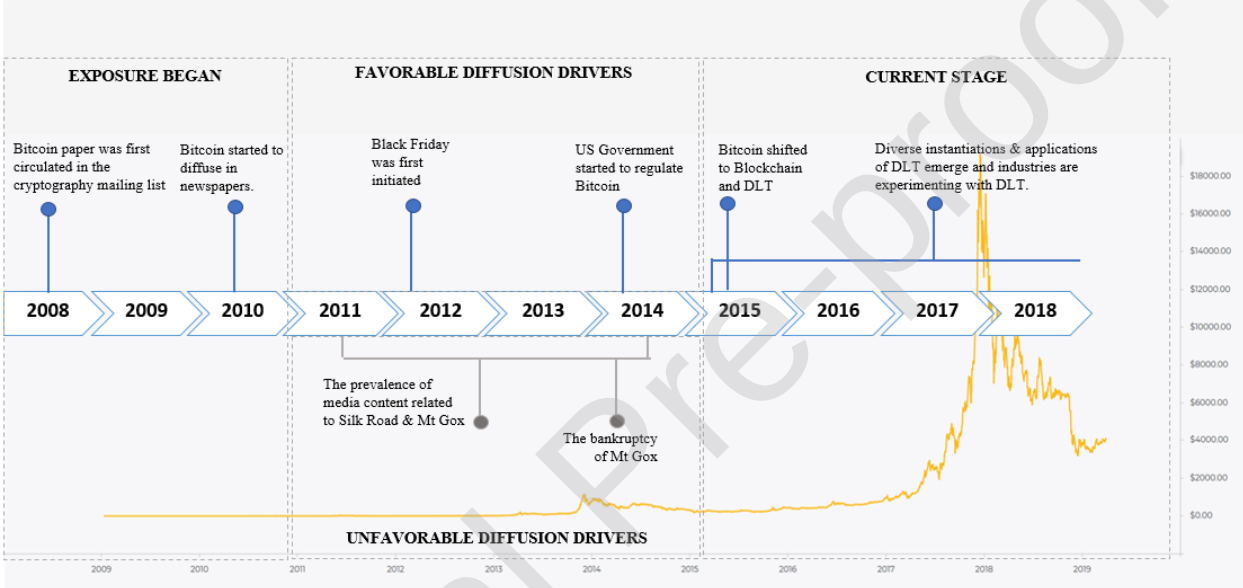
In 2018, the *Bitcoin* theme remains in the concept map (see Figure 4 Panel B). Our observation of the news media excerpts reveals that in early 2018, the media continued to publish news of Bitcoin's (significant) price volatility. Bitcoin peaked at USD 19,783 at the end of 2017. The price, however, tumbled in 2018. Other than Bitcoin, four themes emerged in the concept map, namely, *Financial*, *Industry*, *Technology*, and *Venture*. Industry and technology themes reflected the continuing effort from industry to experiment with Blockchain. Media, however, also reported doubts on the maturity of Blockchain applications to replace existing systems. In the *Technology* theme, government and cryptocurrency appeared as concepts. These two concepts may represent the heated discourse on the regulation of Blockchain applications. The public and government both demanded tighter regulation to limit cryptocurrencies' use for illicit activities, and to minimize and mitigate the potential risks associated with initial coin offerings (ICOs). The *Venture* theme reflected the ongoing interest of venture capitalists in Blockchain-related technologies.

Summary of DLT Diffusion and Its Sentiments

The news media has chronicled DLT's essential milestones since its inception to its status as of 2018. In 2008, after Nakamoto's paper emerged, the idea of Bitcoin was neither readily nor widely understood. Around 2010, the first newspaper article to appear did not mention Blockchain or DLT but focused on Bitcoin. While O'Brien's [56] article described Bitcoin as a strange idea, by mid-2011, content advocating Bitcoin was more visible, with articles about Bitcoin's four principles: decentralization, tamper-resistance, pseudo-anonymity, and ready online availability starting to appear (e.g., [57–59]). Despite promoting the advantages of Bitcoin, the questionable activities related to it arguably gained more attention, leading to perceptions that Bitcoin was a risky, but potentially beneficial technology (e.g., [60,61]).

The early stage of DLT diffusion was concerned more with dubious activities, stimulating discussion among governments and practitioners, and generating media headlines. Bitcoin had virtually no value until 2010 when the first Bitcoin exchange started operating in April 2010. Bitcoin was first initially valued at USD 0.0009 [62]. Over time, two major unlawful activities dominated DLT diffusion: the use of Bitcoin for dubious purchases on Silk Road and the bankruptcy of Mt Gox [61,63]. These two events were important milestones in DLT's diffusion by alerting the public to the concerns surrounding DLT. Figure 5 presents the timeline of the DLT diffusion overlaid with Bitcoin's price history from 2008 to end of 2018.

Figure 5. DLT Diffusion Timeline and Bitcoin Price History



Because content related to Silk Road remained highly visible until 2014, Bitcoin's diffusion to a wider public was increased and produced wider interest. While Silk Road remained visible in the media, Mt Gox's bankruptcy in 2014 worsened Bitcoin's already tarnished reputation and undermined its ecosystem's credibility. The bankruptcy was said to have resulted from a security breach, technical deficiencies, and mismanagement [61,64]. In 2019, Mark Karpelès, chief executive of the defunct Bitcoin exchange Mt Gox was sentenced to prison for falsifying electronic records. Bitcoin's price tended to decline steeply by the end of 2015. However, in early 2016, Bitcoin's price increased markedly, peaking at USD 19,783.06 by the second week of December 2017. In the first week of January 2018, Bitcoin price slumped to USD 14,754.73.

We speculate that the publicity surrounding Bitcoin and its association with dubious activities on Silk Road contributed to the first Bitcoin price fluctuation in early 2011 when it peaked at USD 29.50. Bitcoin's price then remained steady until mid-2013. The first wild fluctuation occurred in mid-2013 because of

increased trading volumes at *Mt Gox*. Bitcoin's price rose rapidly peaking at USD 1,094.14 by the end of 2013. Following the risky and uncertain circumstances of *Silk Road* and *Mt Gox* and their association with Bitcoin, governments started to regulate virtual currencies' transactions. Because the US Senate expressed concerns with Bitcoin's use in online drug markets, the US Department of Justice Department moved to terminate *Silk Road* [60]. Several states and authorities: the *New York State Government*, *Consumer Financial Protection Bureau*, the *Securities and Exchange Commission*, and the *Internal Revenue Service* were prompt to propose regulating Bitcoin. The regulations aimed to protect companies and their customers from risks that might arise when transacting with Bitcoin.

Apart from two negative milestones, DLT diffusion also had a notable constructive event: *Black Friday* [65]. Proposed by Holmquist in 2012 to promote Bitcoin transactions and to reduce its negative reputation, the event successfully encouraged merchants to offer discounts to attract customers to spend their Bitcoins, thus leading to a significant number of transactions. Guided by network economics, by encouraging more merchants and customers to use Bitcoin, the more likely it was to be widely accepted and to be sustainable [66].

Table 2. Disappearance and Reemergence of Particular DLT-related themes

2010-2011	2012	2013	2014	2015	2016	2017	2018
Bitcoin	Card	Currency	Currency	Bitcoin	Bitcoin	Bitcoin	Financial
Online	Online	Payment	Exchanges	Bank	Companies	Services	Industry
Security	Currency	Business	Transactions	Innovation	Blockchain	Financial	Technology
		Market	Payment	Market		Business	Venture
		Website					Bitcoin

In addition to observing DLT's diffusion timeline, we observed the disappearance and reemergence of particular Leximancer themes within the period 2010–2018 (see, Table 2). Three themes: online, payment, and currency continued to appear in the Leximancer maps in certain periods before they disappeared. Market also followed a similar pattern to the aforementioned three themes. Market appears in 2013's concept map. It shifted to exchanges in 2014 and reverted to the market in 2015. Bitcoin first emerged in 2010. From 2015 to 2018 the concept maps show the reemergence of Bitcoin. This Bitcoin reemergence likely reflects further technological development and refinement of DLT in the cryptocurrency area. Additionally, *financial* appeared as a theme throughout 2017 and 2018.

The preceding overview indicates that the textual analytics reveal a pattern of DLT diffusion in transition from its infancy, through growing awareness of its potential, and through favor and opposition to

its applications. We note that the context contributes significantly to DLT's diffusion. Additional sentiment analysis reveals that the likelihood of unfavorable sentiment toward Bitcoin remained higher than favorable sentiment. In contrast, media generally favored Blockchain and DLT. The exploration of excerpts in the news media data showed that unfavorable words occurred when the media published their concerns about Bitcoin's complexity, risks, and association with illegal activities. Conversely, the media was more likely to mention Bitcoin favorably when covering its potential to promote more efficient electronic transactions. Table 3 presents DLT's sentiments in the media.

Table 3. DLT Sentiments in the Media

DLT-related Terms	Favorable Sentiment		Unfavorable Sentiment	
	Count	**Likelihood**	**Count**	**Likelihood**
Bitcoin	2,380	31%	1,841	32%
Blockchain	1,550	20%	817	14%
Distributed Ledger Technology	177	2%	76	1%

Overall, the context has shaped public understanding of DLT, for example, Bitcoin was frequently published as the emerging cryptocurrency. Such repetition introduces Bitcoin's potential for further investigation and experimentation for multiapplications with the same underlying technology. Over time, the focus on Bitcoin shifted to Blockchain and then to DLT. Along the way, Bitcoin was redeemed from its questionable past to a more regulated and attractive technology. Such growing attraction has been reflected in numerous and broader applications of DLT, such as smart contracts and digital assets management.

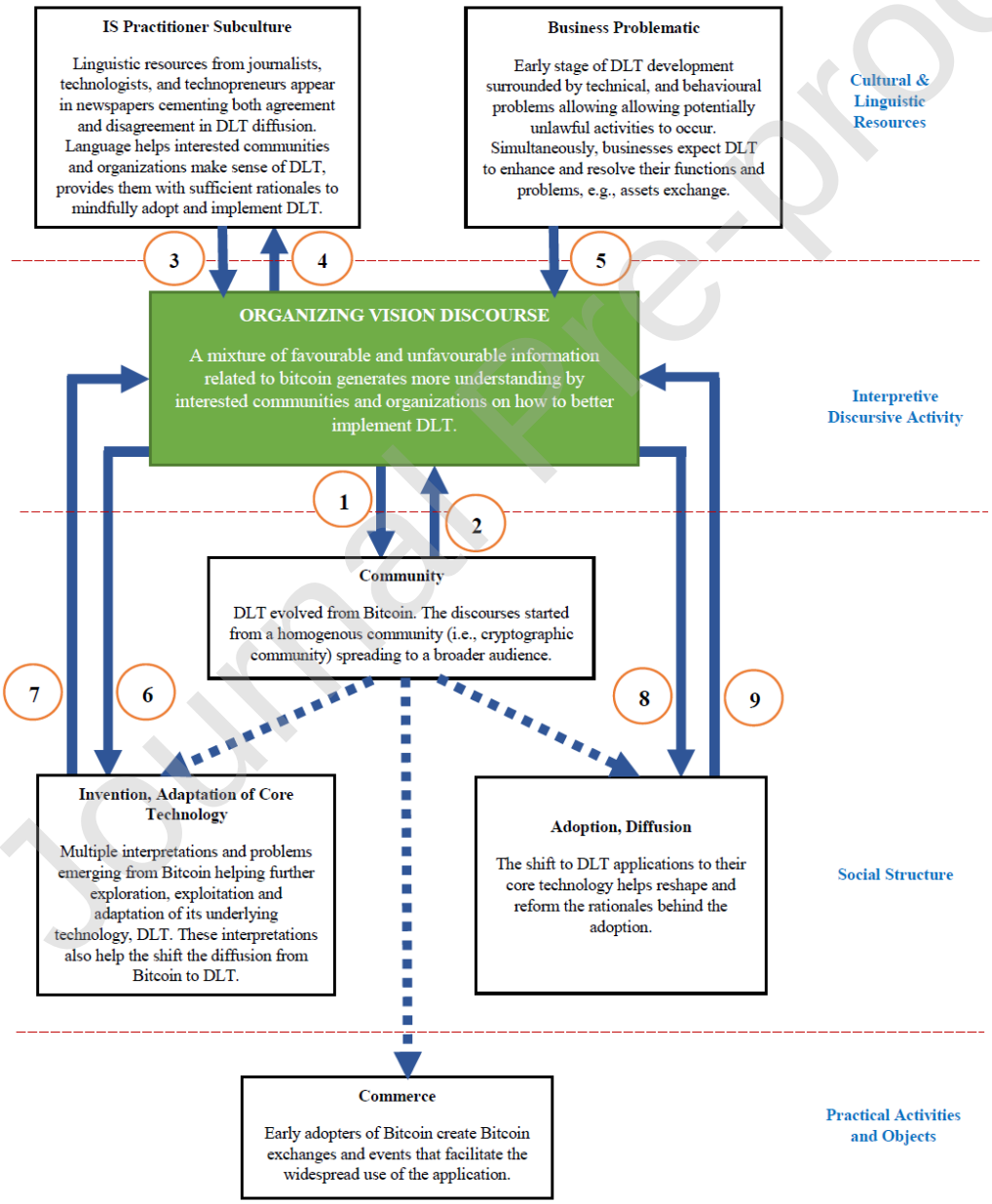
The Organizing Visions of DLT

DLT's diffusion reveals insight from contextualization and media's role in that diffusion. Organizing visions theory notes that diffusion comprises three aspects namely, interpretation, legitimation, and mobilization. Following this notion we will elaborate how the three aspects work in DLT's diffusion (see Figure 6) [11]. The figure shows the extent to which the three aspects relate to DLT diffusion through institutional forces and layers.

The interpretation aspect of DLT combines uncertainty, risk, and optimism about the technology. The DLT idea radiates from a homogenous community to a broader audience. It generates discussion and interpretation across a spectrum of the audience (see social structure layer in Figure 6). The role of journalists in diffusing the communities' discussions and interpretations and promoting DLT contributed

to its increasingly positive status. Interpretation plays a significant role in shaping the vision of DLT (see interpretive and discursive activity layer in Figure 6). The repetition of Bitcoin information in the media helped the public rationalize DLT, perhaps unintentionally, as Bitcoin's underlying technology. More specifically, media content helped the public to understand the technology and learn the *know-what*, the *know-why*, and the *know-how* of DLT. Further, business problems can motivate experimenting with DLT adoptions (see cultural and linguistic layer in Figure 6).

Figure 6. Organizing Visions of DLT



The interpretation of DLT played a critical role in shaping its vision. By presenting both favorable and unfavorable information, the media encouraged awareness and interest, and thus emerging and shifting ideas about Bitcoin and DLT. DLT diffusion is repeated and altered as the technology evolved from cryptocurrency to broader (perhaps, more conventional) use. Regarding organizing visions, we note that DLT diffusion is heavily shaped during interpretation. The negative reputation of Bitcoin contributed to rapid DLT diffusion with its proponents and opponents seeking common ground about how to better implement the technology (see practical activities and object layer in Figure 6).

The legitimation aspect of DLT diffusion is largely motivated by businesses' and organizations' keen interest in solving problems and enhancing their functions [11]. Regarding DLT, its legitimation might be driven by its ability to transform business processes such as storage, recordkeeping, and the exchange of digital assets [16,23]. The diffusion of DLT exemplifies a case of devoting significant effort to shape the rationale for its adoption. While DLT started its diffusion with the *enfant terrible*, Bitcoin, proponents of Bitcoin proposed innovative uses and quickly shifted focus from Bitcoin to DLT (see cultural and linguistic resources layer in Figure 6).

DLT will likely gain more legitimation once the early adopters, who serve as role models for DLT legitimation, successfully adopt and experiment with it. Our sample data show that, once the shift from Bitcoin to DLT occurred, organizations started experimenting with diverse DLT applications designed to resolve problems and enhance their businesses. For example, the banking and finance sectors are experimenting with DLT to expedite their settlement and clearing processes, and to advance their digital assets management. Additionally, the involvement of government, industries, and professional bodies in formulating DLT regulations and policies contributes significantly to its legitimation. Such environments set boundaries on risks and benefits in adopting and implementing DLT (see practical activities and objects layer in Figure 6).

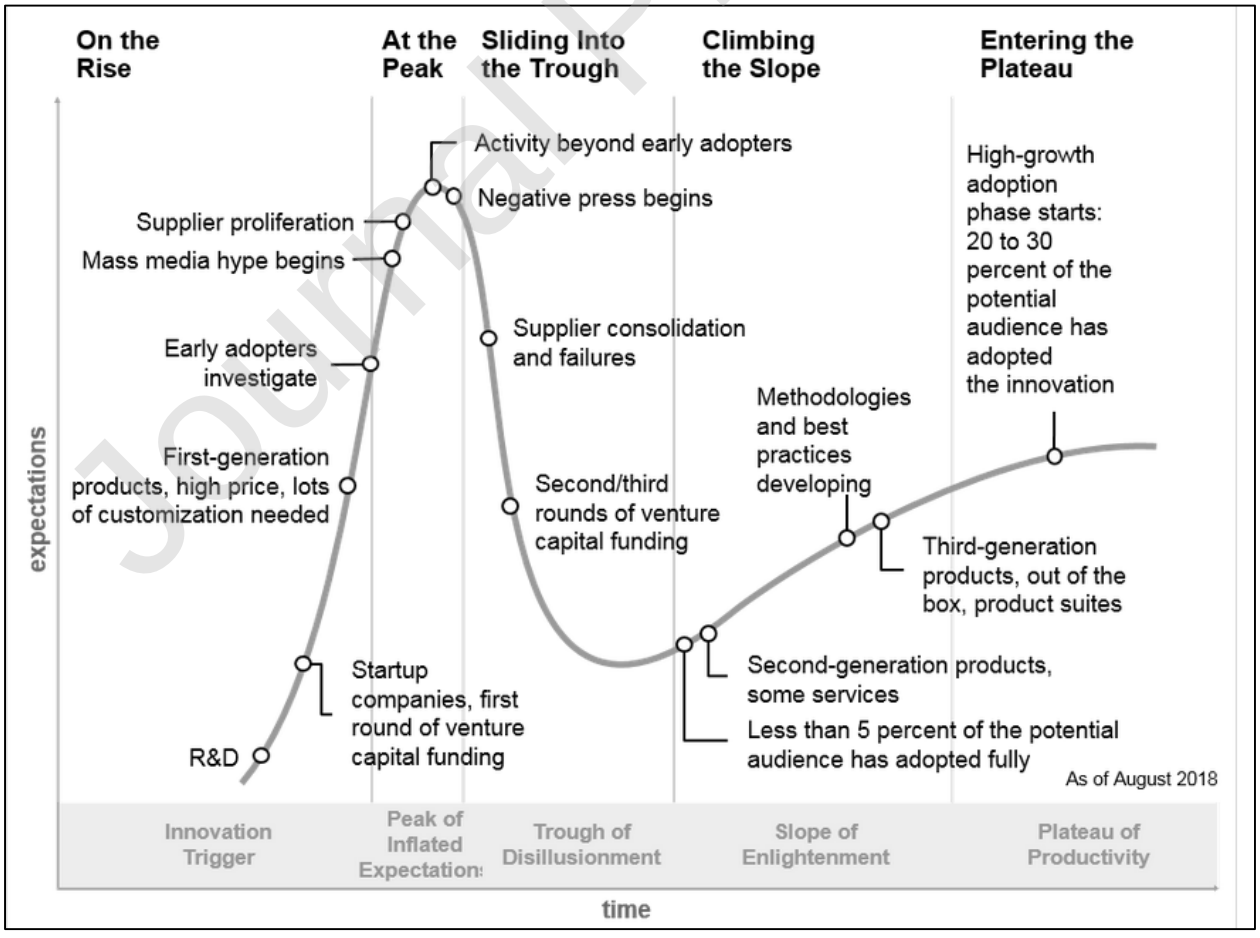
The mobilization of DLT is inextricably linked to the role of early adopters in triggering and realizing the supporting environment for Bitcoin (see practical activities and the objects layer in Figure 6). For example, early adopters of Bitcoin involved in entrepreneurial activities created Bitcoin exchanges and

initiated Black Friday to attract more merchants and customers to its use. Further, investors seeking to profit from the wide fluctuations of the Bitcoin price contributed to the growth of DLT applications in cryptocurrency. This mobilization aspect has helped make DLT practicable. The realization of Bitcoin in businesses and marketplaces helps understanding about how Bitcoin works, modifies, and advances other applications of DLT, and resolves DLT's shortcomings. The realization leads to better implementations, for example, the Red Belly Blockchain with its potential for credit card levels of transaction throughput.

The Hype Cycles and DLT

Our sample data indicate that DLT promises to hasten the transformation of business practices. To help validate such a statement, we use the Gartner hype cycle to predict the eventual status of DLT in the market. The hype cycle comprises of five stages: technology trigger, the peak of inflated expectations, the trough of disillusionment, the slope of enlightenment, and the plateau of productivity [12]. The stage where the emerging technology is located can indicate the eventual position of the DLT-related applications compared to other emerging technologies in the market. The stage also helps to identify what kind of research should be conducted to further develop DLT [13,14]. Figure 7 presents the hype cycle stages (at the base), phases (at the top), and eventual positions of the emerging technology (on the line). Table 4 presents the stages, phases, and eventual positions of DLT in the hype cycles from the period 2010 to 2018.

Figure 7. Phases of the Hype Cycle [12]



While DLT-related applications are absent from the hype cycle until 2014, cryptocurrencies have notably appeared in the media since 2010.

Table 4. DLT in the Hype Cycles

Panel A: DLT-Related Technologies Appeared as Cryptocurrency and Cryptocurrency Exchange				
Annual Hype Cycles	**DLT-related applications**	**Stages**	**Phases**	**Eventual Positions in the Hype**
2010	N/A	N/A	N/A	
2011	N/A	N/A	N/A	
2012	N/A	N/A	N/A	
2013	N/A	N/A	N/A	
2014	Cryptocurrencies	Peak of Inflated Expectations	At the Peak	Negative press begins
2015	Cryptocurrencies	Peak of Inflated Expectations	At the Peak	Between "Negative press begins" and "Supplier consolidation and failures."
	Cryptocurrency Exchange	Trough Disillusionment	Sliding into the trough	Between "Second/third rounds of venture capital funding" and "Less than 5 percent of the potential audience has adopted fully."
Panel B: DLT-Related Technologies Appeared as Blockchain				
Annual Hype Cycles	**DLT-related applications**	**Stages**	**Phases**	**Eventual Positions in the Hype**
2016	Blockchain	Peak of Inflated Expectations	At the Peak	Supplier proliferation
2017	Blockchain	Peak of Inflated Expectations	At the Peak	Between "Negative press begins" and "Supplier consolidation and failures."

Panel A: DLT-Related Technologies Appeared as Cryptocurrency and Cryptocurrency Exchange				
Annual Hype Cycles	**DLT-related applications**	**Stages**	**Phases**	**Eventual Positions in the Hype**
2018	Blockchain	Trough of Disillusionment	Sliding into the trough	Supplier consolidation and failures

Cryptocurrency appeared in the 2014 hype cycle at the "Peak of Inflated Expectation" stage in the "At the Peak" phase, eventually settling at the "Negative Press Begins" position. While the 2015 hype cycle starts with cryptocurrency at a similar stage and phase, its position slid from "Negative Press Begins" to "Supplier Consolidation and Failures." Notably, in 2015, the hype cycle positions cryptocurrency exchange at the "Trough of Disillusionment" stage and in the "Sliding into the trough" phase. Cryptocurrency exchanges were positioned between "second/third rounds of venture capital funding" and "less than 5 percent of the potential audience has adopted fully" in the hype cycle.

The hype cycle placed Blockchain at the "Peak of Inflated Expectations" stage in 2015. In 2016, Blockchain was in the "At the Peak" phase and had settled at the "Supplier Proliferation" position. Blockchain remained "At the Peak" phase in 2017. However, it has settled between "Negative press begins" and "Supplier consolidation and failures." In 2018, Blockchain was at the "Trough of Disillusionment" stage and moved from "Negative press begins" to the "Sliding into the trough" phase. It stayed at the "Supplier consolidation and failures" phase.

A comparison between our sample data and the status of DLT-related applications in the nine-year period of hype cycles reveals four features of DLT diffusion. First, as an innovation, DLT does not appear on the hype cycle because of its characteristics (e.g., its multiple applications and benefits). Rather, DLT initially appeared on the hype cycle because of its Bitcoin application. Second, a time lag apparently occurred between the media hype related to DLT and its related applications, and the appearance of cryptocurrency in the hype cycle in 2014; we speculate that this time lag was triggered by Bitcoin. Our sample data show that unfavorable cryptocurrency media, particularly related to Bitcoin, started in 2011 and persisted till 2014. During this period, Bitcoin articles proliferated and seemed more pessimistic than optimistic about the cryptocurrency's future. Third, from 2014, and aligning with our data, investors and venture capitalists funded cryptocurrency companies and startups, and cryptocurrency exchanges appeared in 2015 at the "Trough Disillusionment" stage. They continue to flourish, the failure of Mt Gox notwithstanding. Fourth, the absence of cryptocurrencies and cryptocurrency exchanges from the 2016 hype cycle does not necessarily indicate that cryptocurrencies and/or cryptocurrency exchanges finished before

the plateau. We speculate that their absence suggests that the cryptocurrency label has been included in the broader Blockchain term [12]. Following Fenn & Blosch's [12] note, innovations may be renamed or included within a broader technology category rather than moving to another stage or phase in the hype cycle. Blockchain began being used instead of cryptocurrency and cryptocurrency exchanges in the 2016 hype cycle. Such displacement is supported by our sample data that confirm the shift from Bitcoin to Blockchain/DLT that started in 2015. Table 5 presents the summary of research questions, proposition, and findings of our research.

Table 5. Summary of Research Questions and Proposition

Research Question & Hypothesis	Summary of Findings
RQ: How are Bitcoin, Blockchain and DLT being interpreted, legitimized, and mobilized since its inception?	The diffusion of DLT exemplifies a case of significant effort from communities to shape the rationale for DLT adoption. The interpretation stage of DLT diffusion through its infamous application – Bitcoin played a critical role in the rapid diffusion of DLT, engaging proponents and opponents, alike. The competing discourses between communities solidified DLT diffusion and helped them to seek common ground about how to better implement the technology. The legitimation stage occurred once the communities started experimenting with diverse DLT applications to resolve and enhance their business processes and/or problems. Those who successfully adopt and experiment with DLT-related applications became role models and enhanced DLT legitimation. Further, the involvement of government, industries, and professional bodies in formulating DLT regulations and policies to minimize and mitigate any potential risk from DLT-related technology contributed to its legitimation. The mobilization stage is driven by entrepreneurial activities. Investors and venture capital funding helped enable the realization of DLT-related applications in business and marketplaces.

Research Question & Hypothesis	Summary of Findings
P: DLT diffusion follows Gartner hype cycle	Our text and interpretive analysis reveals that DLT diffusion follows the Gartner hype cycle's stages, phases, and eventual positions status. DLT first appeared in the Gartner hype cycle in its cryptocurrency guise and as cryptocurrency exchanges between 2014 and 2015. The cryptocurrency terminology was then displaced by Blockchain starting in 2015 until 2018. Such displacement concurs with our sample data reflecting the move from Bitcoin to Blockchain/DLT terminology starting in 2015. The absence of cryptocurrency since 2016 may not necessarily reflect that the technology disappeared from the hype. Separating DLT/Blockchain from its applications like cryptocurrency is unfeasible, thus, cryptocurrency may confound the hype of Blockchain/DLT, e.g., through its business use or price volatility. Our interpretive analysis appears to support our contention that DLT diffusion follows Gartner hype cycle. Thus, P1 is supported.

V. DISCUSSION

Research Contributions

Given the increased interest and uptake of DLT in the media and academia, we explored the diffusion of the technology by analyzing the results of the diffusion and the extent to which DLT could be better developed. The contribution of our paper is threefold. First, using organizing visions theory, we find that the media and the language of journalists, technologists, and technopreneurs are important in increasing the audience reach of DLT. It is a complex technology that can prove difficult to comprehend by laypersons or nonexperts. Media lessens this complexity by describing its diffusion in more readily understandable ways. Media hype, constant DLT-related articles in the media, and competing arguments from promoters and detractors serve to heighten public, organizational, and government awareness of, and interest in, DLT despite its early association with shadowy transactions.

Organizing visions theory refers to the circumstances in which communities dynamically form and reform their understanding when shaping their visions about a focal IT innovation [11,30]. While organizing visions has helped us frame our data, the essential finding from our analysis is the motivation behind the three aspects: interpretation, legitimation, and mobilization. Our second contribution is to identify events responsible for accelerating DLT diffusion: Black Friday, the Silk Road seizure, and Mt Gox's bankruptcy. We contend that these events are the most obvious motivations of DLT-related

publications in the media. They likely stimulated the public, organizations, and governments to consider the technology and look beyond its negative associations. The events moved governments to better regulate DLT, encouraged technopreneurs to develop diverse DLT applications, and to create more viable, reliable, and secure marketplaces.

Our sample data help us to comprehend the history of DLT. The comparison between the hype cycles and our sample data lead to the third contribution of our study. The eventual positions of DLT-related applications help researchers to undertake more relevant research. Three DLT-related applications appear in the hype cycles since 2014: cryptocurrencies, cryptocurrency exchange, and Blockchain. They appear to have become included within the broader Blockchain term and are presently located at the "Trough of Disillusionment" stage. They also indicate that researchers should take an active interest in investigating the technology. The literature about DLT appears to be more technical than conceptual, exploratory, and empirical. This could create opportunities for nontechnical researchers to contribute further to DLT's development. In the next section, we discuss the niche areas that researchers could potentially pursue in the DLT research stream.

Research Agenda

Our sample data show that the term, DLT, emerged around 2015. Thus far DLT has evolved from a shadowy cryptocurrency to enabling smart contracts. DLT has found potential application in the banking and finance industry, asset management, and government, and will likely affect industries involved in data exchange and third-party intermediations [20]. More specifically, DLT is able to provide trustless proof mechanisms that ensure integrity and verifiability when exchanging data [10].

Departing from its history and evolution, we use DLT rather than Blockchain because we wish to suggest future research that is broader. Our sample data about DLT diffusion and evolution align with the Blockchain development/roadmap of Blockchain adoption proposed by Swan [16] and Hughes, Park, Kietzmann & Archer-Brown [8]: Blockchain 1.0 (currency); Blockchain 2.0 (contracts); and Blockchain 3.0 (beyond currency). Based on its evolution, multiple applications have emerged from DLT, including anti-counterfeit platforms, asset protection, Blockchain-based accounting, cryptocurrency, digital audit, and attestation services, decentralized autonomous organization, decentralized prediction platform, financial inclusion acceleration tools, smart contracts, and smart controls.

The emergence of DLT could encourage researchers to resolve issues associated with behavioral, policy, and technical aspects of DLT's development and implementation. Future research opportunities might fall in three broad areas. First are DLT design, adoption, implementation, and use cases. Second is measuring the impact of DLT on individual users and organizations, and third is multiple DLT applications

in industries, public institutions, and information and communications technologies for development (ICT4D).

The first area open to researchers is to investigate DLT's technical design and the level of DLT adoptions. Regarding DLT's design, ensuring the security mechanism is essential to minimize security incidents. For example, the Blockchain mechanism's design assumes that the network is fully populated with authentic users. If attacker nodes have more collective computational power than valid nodes, the network falls under the control of the attackers. The decentralized model is disadvantaged when most of the nodes are malicious and the participating nodes have the power to decide outcomes. While Bitcoin was designed as a fully decentralized network, it is increasingly becoming centralized to the extent that the centralization factor has increased from 0.26 in 2011 to 0.33 in 2014, i.e., there are several large mining pools with substantial influence in the Bitcoin network [67]. Further, it is because of the large monetary incentives, frauds and scams that are increasing rapidly in the Bitcoin network. Vasek and Moore [68], for example, track various online resources and voluntary observers to examine Ponzi scams, mining scams, scam wallets, and fraudulent exchanges. They found that, within one year (from Sept 2013 to Sept 2014), 13,000 victims lost around $11 million in Bitcoin scams. Given these issues, better design and implementing of the network offers substantial research scope. Such improvements will cater to specific domains retaining DLT's distributed nature, at the same time preventing a majority of malicious nodes from taking control.

DLT adoption, implementation, and use are open to researchers to investigate which influences (e.g., organizations, governments, and individuals) are the most relevant inhibitors or drivers. Janssen, Weerakody, Ismagilova, Sivarajah, and Irani [69] for example, proposed a conceptual framework for evaluating Blockchain adoption from institutional, market, and technical factors. These factors may become potential deterrents or accelerators for Blockchain adoption. The barriers for DLT adoptions may originate from behavior, design, regulation, and functionality. For instance, the adoption of a DLT-based application in the construction sector is affected by the lack of trust and limited collaboration among the participating companies [70]. This finding may imply a correlation between successful DLT adoptions and organizations sharing their data and collaborating. A major factor that could hinder the adoption of DLT in various industries is the lack of technological readiness of the companies. DLT may be novel and a potential excellent business problem/process solution, but the possible participant companies may not have the technological infrastructure, competence, and means to adopt DLT-based solutions. This outcome may lead to resistance to change, and thus not taking full advantage of benefits offered by the implementation of DLT [71]. Early adopters' experiences with DLT-related applications' use may prove useful for organizations considering future DLT commitments.

The second area of research is concerned with the impact of DLT on organizations. The considerable resources required for adopting and implementing DLT would mean that researchers would need to evaluate the impact of DLT on organizational performance. A major concern arising from business entities relative to DLT is the lack of instruments to better understand DLT and to make informed predictions on how it could impact companies or industries [72]. The impact may be quantitative (e.g., accounting and financial performance) or qualitative (e.g., customer satisfaction and the effectiveness and efficiency of organizational processes). DLT approaches may suit differing firm sizes, industries, processes, and levels of expertise. Studies, for example, could be conducted at different levels from investing in new DLT infrastructure to using the Blockchain as a service model (BaaS). Intuitively, industry leaders could leverage investments in DLT frameworks that support their industry standards. Various industry players who have already invested in such endeavors could be studied. In contrast, small scale businesses may choose a BaaS model in preference to setting up their own infrastructure. Performance evaluations and cost benefits of both DLT approaches could shed light on which strategies work best for companies contemplating DLT adoption. Further, practice may also benefit from research into the impact of DLT on professionals, such as accountants, auditors, and bankers. More specifically, focusing on the skills that these professionals should possess and develop due to DLT's changing and changed environment.

The third research area provides broad opportunities for researchers to extend the application of DLT, e.g., a Blockchain-based accounting ecosystem [24]. This ecosystem could provide more secure accounting transaction recording, continuous auditing, and automated assurance. McCallig, Robb & Rohde [25], for example, offer a Blockchain-based solution to enhance the representational faithfulness of financial reporting information that will benefit audit processes. DLT applications can also be extended for law enforcement and compliance [73,74]. More specifically, tracking the sources and destinations of funds and permitting analyses of potentially suspicious transaction patterns, thus allowing law enforcement agencies to more readily identify fraud-related activities. DLT would be valuable to businesses legitimately involved in the application eco-space. Such businesses need to ensure that they comply with KYC-AML (Know Your Customer-AntiMoney Laundering) legislation, particularly in Europe, North America, and Australia/New Zealand.

The DLT ecosystem can be expanded to domains beyond just financial transactions. Any centralized institutions with a substantial number of participants can leverage the distributed nature of DLT systems. For instance, the energy industry has historically been centralized whereby generators, through retailers, sell energy to consumers. With the advent of green energy technologies, consumers can also generate power. *NRGCoin* is a virtual currency designed for trading renewable energy in smart grids [75]. Similarly, *GemOS* is a commercial Blockchain-based system that focuses on healthcare sharing and supply chain management. It also provides the healthcare industry with the facility to secure patient data by adding it to

a Blockchain that can be shared across departments in real time. *IoT-coin* is another area where DLT technology is used to generate a cryptocurrency for internet of things (IoT) devices [76]. DLT can also be used for auto-insurance claims by tracking sensor data and entity interactions [77].

The potential of DLT applications not only impacts private organizations, but can also benefit public institutions and society, more broadly (e.g., World Food Program (WFP)/WFP Building Blocks, Helperbit, and Sikka) [8,78,79]. The WFP building blocks program uses permissioned DLT and biometric for cash-based transfer, which permitted Syrian refugees to receive e-money without the need of bank accounts. The refugees could use e-money and retina scans to purchase groceries[4]. Helperbit enabled humanitarian donations using Bitcoin and Altcoin[5]. Sikka was created to address the challenge of cash distribution after the earthquake crisis in Nepal[6]. Overall, the varied nature of the new instances embracing DLT demonstrates the scalability of the technology, by showing how it can contribute more broadly to disparate applications and ICT4D. Table 6 summarizes the three DLT research areas.

Table 6. DLT research areas, opportunities, and methods

Research Areas	Research Opportunities	Research Methods
DLT design, adoption, implementation, and use case	• DLT technical design • DLT levels of adoption • Drivers and inhibitors of DLT's adoption including behavioral, design, functionalities, and regulation	Design Science, Case study, Survey, and Experiment
The impact of DLT on users and organizations	• Performance quantities and qualities • Impact of DLTs on professionals	Case study, Archival, and Survey
Multiple DLT applications in industries, public institutions, and ICT4D.	• DLT-based accounting ecosystems • Law enforcement and compliance • DLT solutions for energy industry • DLT in supply chain management • DLT solutions for ICT4D	Case Study and Design Science

[4] https://innovation.wfp.org/project/building-blocks
[5] https://app.helperbit.com/
[6] https://www.sikka.me/

VI. LIMITATIONS AND CONCLUSION

Our research has two main limitations. First, our description of the evolutionary path of DLT and the emergent features of its diffusion is based on the sample data and restricted timeframe (from 2010 to 2018). The data may bias our findings toward journalistic perspectives and the language. We analyzed only English language popular news as our sample data. Future research, therefore, may incorporate other languages, for example, both China and South Korea have substantial Blockchain media publications. Perhaps, future research may analyze specialist media, for example, peer-reviewed journals that cater to academia and/or practice. We used calendar years as the reference points based on the volume of data. We are aware that the use of calendar years may produce misleading results. Future research may use other reference points. While our data can sufficiently detail and explain DLT's diffusion, our research's ability to identify the extent of other actors' (e.g., investors, academics, technopreneurs, and professionals) contribution to DLT diffusion is restricted. Future research could examine how academics perceive the research and development of DLT.

Second, our investigation using the annual Gartner hype cycle is limited to DLT's related applications (i.e., cryptocurrency, Blockchain, and cryptocurrency exchange). While one may argue that DLT also has relationships to internet payments, decentralized applications, distributed storage, and cryptography technology, our observation is focused on the evolution of DLT since the emergence of cryptocurrency, in particular, Bitcoin. Apart from the hype cycle for emerging technologies, Gartner also released a special hype cycle for Blockchain Technologies, 2017.[7] This type of hype cycle could motivate broader research into how technologies progress, provide lessons for their successors, converge on a broader technology, and/or diverge from the same core technology.

In conclusion, we described the critical features of DLT diffusion and its impact on future research. DLT and its related technologies have seen significant hype in recent years. Our study enables us to comprehend the role of media influences on DLT diffusion. The popular news media led the way in helping the public to better understand the technology, including its shortcomings and potential benefits. The media has continued to raise awareness of DLT, among the public, and governments and their regulatory bodies, and thus hastened its legitimacy. Further, the media also appears to help mobilize entrepreneurial activities involving DLT. Noting its evolution to date, future developments of DLT are likely to differ from its early presence with multiple new DLT-related applications soon emerging. By highlighting the potential research areas, we hope to contribute to researchers' willingness to pursue future DLT research agendas.

Author Statement

[7] https://www.gartner.com/doc/3775165/hype-cycle-blockchain-technologies-

Arif Perdana: Conceptualization, Methodology, Formal analysis, Investigation, Writing- Original draft preparation, Writing- Reviewing and Editing, Visualization. **Alastair Robb**: Formal analysis, Writing- Reviewing and Editing. **Vivek Balachandran**: Writing- Reviewing and Editing. **Fiona Rohde**: Writing- Reviewing and Editing

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