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A BIBLIOMETRIC OVERVIEW OF BLOCKCHAIN TECHNOLOGY IN SPORTS

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Abstract. *Blockchain Technology - Hype or Fad? This is one of the most popular questions multitudes of technology enthusiasts, policymakers, and businesses have asked. The technology has been projected to have a promising future in spite of its current state of experts beginning to rediscover its true purpose and use case success. A number of domains of discourse such as supply chain, banking and finance, as well as land management have chalked appreciable levels of success with the technology. In this paper, we delve into the world of sports to identify the state of the art with respect to blockchain technology in major sporting activities. The article adopts a computational literature review together with bibliometric analysis methodologies to extract knowledge from scientific publications on the aforementioned goal. Finally, our work contributes to knowledge and practice by providing a snapshot of blockchain technology within the sphere of sports.*

Key words: *Blockchain, Sports, Bibliometric Analysis, Computational Literature Review*

1. INTRODUCTION

In more recent times, the concept of blockchain has taken over conversation spaces and questions have been raised as to whether it is a fad or a promising technological innovation. Blockchain has been synonymous with cryptocurrency and non-fungible tokens (NFTs), yet there have been many numerous everyday use cases such as in land record management, electronic health records, in supply chain (vaccine tracking ,food traceability and automotive industries), as well as in e-government/digital government data interoperability provisioning [1–4]. As visualised in figure 1, a Google trend analysis on the term blockchain for the past five (5) years highlights the rise and and descent of the topic.

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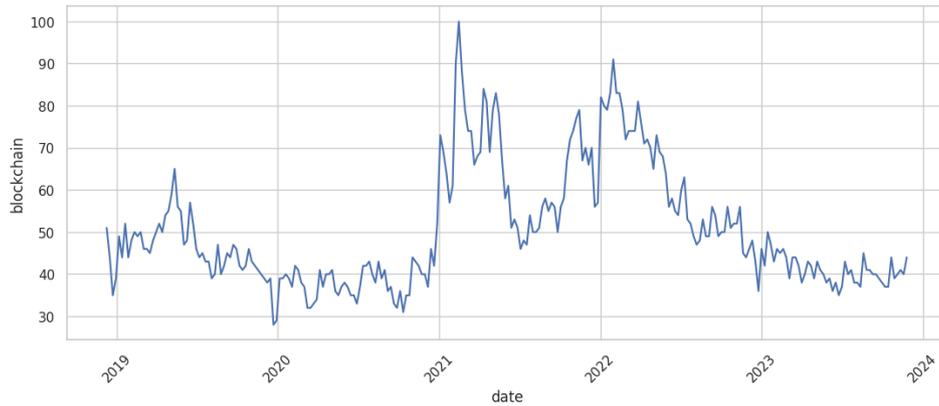


Fig. 1 Five-Year Google Trend Analysis of Blockchain Search Worldwide
(Source: Google Trends)

The simplest definition of blockchain is an open distributed ledger made up of a series of interconnected digital blocks. Its original purpose was to record transactions involving digital currency, but it has subsequently been used for purposes other than currency and payments. Blockchains can be divided into various categories according to their specific uses and characteristics. There are three (3) types of blockchains: 1) public, 2) private, and 3) consortium. Since public blockchains are totally decentralized, everyone can join and take part in running them. Consortium blockchains, sometimes referred to as "federated blockchains," provide a medium ground by allowing invited users from numerous organizations, whereas private blockchains limit participation to individuals from a single organization [5]. The primary reason for the broad applicability of Blockchain is its attributes, which include decentralization, pseudonymity, transparency, democracy, immutability, auditability, fault tolerance, and security. A major factor in the success of Blockchain technology is the accessibility of Application Development Frameworks (ADFs) [5]. Although blockchain technology has received high praise for being a game-changer, there are still a lot of unanswered questions about its utility.

Due to the nature of handling health records, data in manual records is much more susceptible to loss, misuse, or inadvertent erasure. For blockchain applications in healthcare, addressing security concerns at all network infrastructure layers is a critical challenge. In this case, it is crucial to confirm and validate the identities of each participant. Using Blockchain technology eliminates the need for a central administrator, as cryptography assumes responsibility for those tasks, in contrast to the conventional approach [6]. Blockchain might reorganize medical databases for safe distribution, as the healthcare industry needs quick access to patient data while maintaining its privacy. In addition, it creates an open and reliable conduit via which untrusted organizations can interact without needing external verification.

Although blockchain is still in its early phases of development, a group of about 45 big corporations are closely examining its uses and technology. Since transactions are essential to almost every organization, Blockchain is expected to have a substantial impact on a wide range of industries. This is especially beneficial for companies that offer transactional services [7].

Research has focused on blockchain in healthcare, education, supply chain and in public record management aimed at ensuring cost-effectiveness, synchronized transaction processes, traceability (or visibility), and reliability with security [8 - 17]. We observe the proliferation of blockchain in many business processes, yet that of the sports world is rarely researched on, as such we aim to bring to light the state of research with regards to blockchain technology in sports.

2. BLOCKCHAIN TECHNOLOGY IN SPORTS

In recent times, the sports industry has also experienced levels of advancement with regards to technological innovation. Innovative integrations of technologies, such as artificial intelligence (AI), internet of things (IoT), virtual reality and augmented reality (VR/AR). For example, according to research, AI has become one of the most popular digital transformations in sports and has been implemented in the following areas: prediction of match result, strategic and tactical decision making by coaches, fantasy sport games, and injury management [18–21]. AR and VR have also been applied in sports for purposes such as training, education and sports health management [22–24]. Though these technologies have made immense impact in the transformation of sports, blockchain's impact is yet to be realized. Blockchain technology has not been left behind in this technological progress and in its booming era across the globe the sports world is gradually recognizing blockchain's enabling value and researchers continue to carry out theoretical and practical research [25]. This section explores literature on blockchain in sport.

One of the applications is with respect to athlete training and contract management. The use of blockchain technology makes it possible to standardize athlete training and competition management in a scientific manner [26]. Coaches and clubs can view the training and competition records of athletes whose data is saved in a private chain. In addition to offering crucial information for pay reference standards in grassroots sports training, this makes it easier for clubs and sports schools to choose exceptional athletes. A public chain is built to evaluate the worth and potential of athletes as they advance. Customized intelligent contracts for each athlete guarantee consistent transaction procedures, enhancing the overall athlete training program.

Blockchain functions as a regulator for the digital ticket market, mitigating trust concerns that are common in traditional sporting events due to exorbitant fees and regulations [26]. Sports lovers' participation and zeal are adversely affected by these problems. Due to blockchain's global transparency, ticket purchases for distributed sports users around the world are no longer a challenge. Blockchain stops the spread of fake tickets by visualizing ticket circulation and precisely recording each ticket's life cycle. This improves the efficiency of data exchanges and allows for a change in the management mode of bill data recording, transmission, and storage.

Blockchain technology improves communication and settlement efficiency between nations by facilitating cross-border settlement and payment through the issuing of digital tokens [27]. This makes international competitions end sooner. In sports-related sectors like sports information, sports entertainment, and sports malls, tokens can naturally circulate thanks to intelligent contract rules. The blockchain platform tracks goods and services related to sporting events, expanding its impact to neighborhoods that are connected to sporting events. Fan consumption, celebrity endorsements, IP creation, and

other factors are included in this. This connection speeds up the promotion of transparency in sports event transactions by allowing fans to settle and pay for cross-border consumption (see Figure 2).

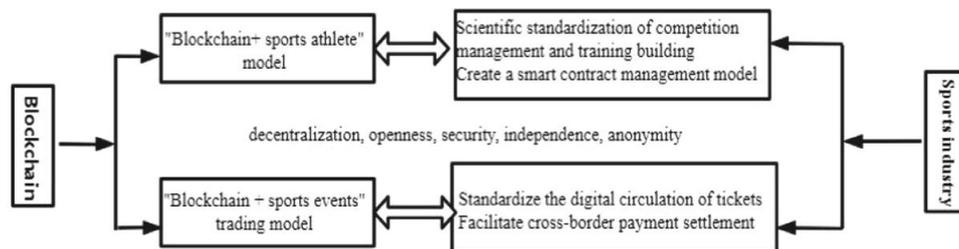


Fig. 2 Application mode of blockchain in sports events [27]

Blockchain is a driving force behind the advancement of data distribution in athletic activities. With the use of this technology, it is possible to encrypt and fully integrate the distribution of event data, improving the tracking of sporting events from start to finish. Athletes and spectators have faster, more accurate, more comprehensive access to event data thanks to blockchain. Coaches can effectively monitor each athlete's personal information at the same time, guaranteeing the traceability of competition and athlete data. This focus on traceability strengthens the transparency of athletic events while also bolstering their fairness. In the end, blockchain helps to improve the legitimacy of distributing and enforcing information about athletic events.

Blockchain is essential for protecting sports copyright, especially when it comes to mementos related to sports [27]. Data chaining over the full lifecycle—which includes raw materials, production, processing, shipping, and sales—is made easier by this technology. Every link in this chain has an anti-counterfeiting code attached to it, making counterfeiting far more difficult and hence decreasing the number of fake items that are available for purchase. Blockchain provides a unique timestamp mechanism that distinguishes sports events and the copyrights linked with them in the context of sports event and brokerage copyright protection. Links to subsequent transactions are safely stored on the blockchain, guaranteeing the safety of sporting events and copyrights for brokerages. In addition to defending the rights of sports copyright holders, this creative use of blockchain technology in the sports copyright development model raises the bar for sports copyright services.

3. DATA AND METHODS

To unveil the extent of research, we adopted bibliometric and computational literature review methods and used literature gathered from a keyword search on Web of Science. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines support the process of obtaining the data for analyzing the literature for the study. We adopted PRISMA in our study to support the selection of the right research materials that align with our study [28]. In addition, our study utilizes computational techniques to extract knowledge from the literature by means of computational literature review (CLR). According to studies though CLR is in its early days, research has commended its use since it contributes to the literature review process [29]. By applying such

knowledge extraction techniques, the study summarizes the state of research as well as themes experts and researchers for future studies.

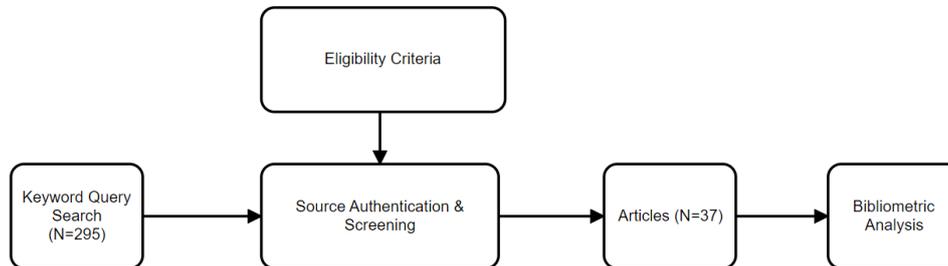


Fig. 3 Research Workflow (Source: Author's own Elaboration)

The keyword search used the following strings: “blockchain” AND “sports, basketball, football, soccer, tennis, athletics, rugby, golf, boxing, cricket, volleyball”. These sports are some of the most popular and highest earning in the world, as such we adopted these for keyword search. A total of 295 articles were obtained, and upon thorough manual screening, irrelevant articles (studies that have no bearing on blockchains application in sports but make mention of both keywords in their abstracts) were eliminated; 37 articles were fit for the study. With respect to the exclusion criteria, all non-English works were eliminated, articles that did not focus on sports and blockchain. Inclusion criteria include all English articles, and all articles that focus on blockchain in sports. The next section highlights the results of our bibliometric and computational review findings.

4. RESULTS AND DISCUSSION

In this section, we expound on the results derived from the selected literature. A brief overview of the 37 articles is as follows: 28 sources (journals and conference proceedings) spanning from 2020 to 2023; authored by 103 authors (with an average of 2.86 co-authors per document), and international collaboration rate of 29.73%; as well as an annual growth rate of 151.98% (as highlighted in figure 4). The top 10 most frequent sources (and their corresponding number of articles) for blockchain and sports publication include: Mobile Information Systems (4), Preventive Medicine (3), EURASIP Journal On Wireless Communications And Networking (2), IEEE Access (2), International Journal Of Sports Marketing & Sponsorship (2), Wireless Communications & Mobile Computing (2), BioMed Research International (1), Business Horizons (1), Economies (1), and Expert Systems (1).

In addition, the top institutes that have contributed three or more articles so far to research within this interdisciplinary sphere are: Linyi University (6 - China), Loughborough University London (4 - UK), National Taipei University (4 - Taiwan), Amity University Chhattisgarh (3 - India), Beijing Sport University (3 - China), GMR Institute of Technology (3 - India), King Faisal University (3 - Saudi Arabia), Minia University (3 - Egypt), Qufu Normal University (3 - China), Xi'an physical Education University (3 - China), and Yong In University (3 - South Korea). The list shows that Asian institutions are leading the charge in research on blockchain technology in sports (as seen in figure 5).

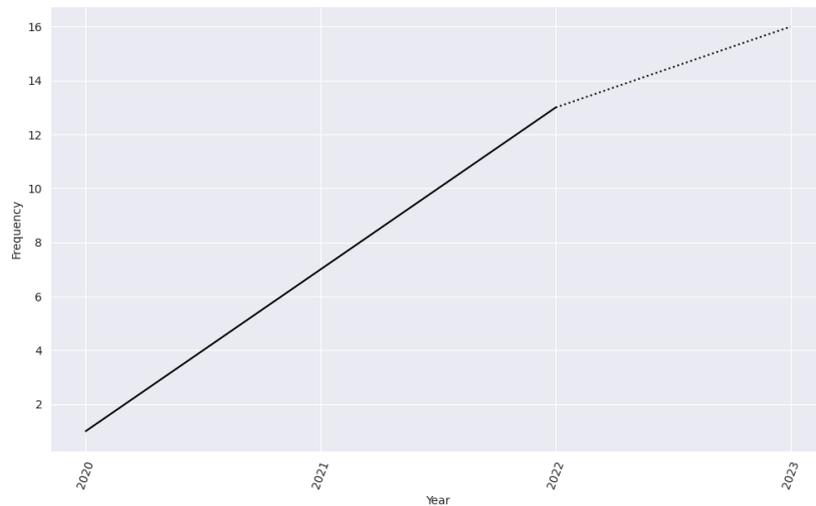


Fig. 4 Annual Research Production (Research on Blockchain in Sports) - (Source: Analytics from Bibliometrix)

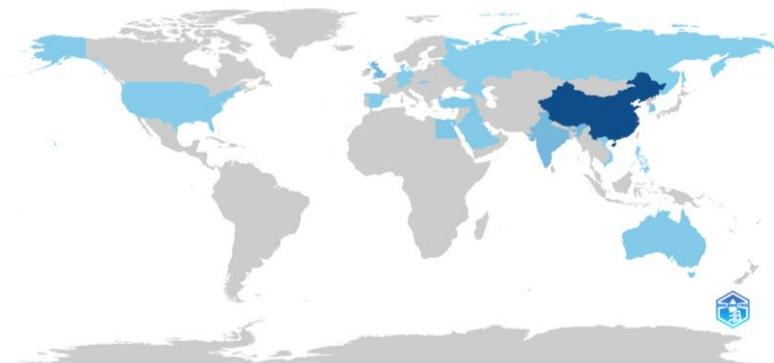


Fig. 5 Research Distribution by Country (Research on Blockchain in Sports) - (Source: Analytics from Bibliometrix)

These observations confirm observations made by research that indicated Asia has become the powerhouse of blockchain R&D and this can be linked to the good foundation within academic circles to pursue research in the area of blockchain [28, 29]. Their study also highlighted the essence of academic institutions partnering with industry and government agencies to further proliferate the practical solutions blockchain has to offer. For the further progress of blockchain in sports, we recommend that research and practical workshops must be held to channel resources, and bridge the gap between the multiple fields (including sports sciences, information systems, system analysis, as well as blockchain programming).

Table 1 illustrates the applications of blockchain in various sports contexts. Blockchain in the sport and sports-entertainment industry has been seen as a means of revitalizing the sports market. In the sports entertainment sphere, blockchain through cryptocurrencies has been

adopted in the gambling ecosystem and research has resorted to this as a means of ensuring safety [45]. From the table, we observe that the applications cut across particular sports and a large majority of the research is focused on conceptual propositions, with a few being based on empirical studies. In addition, a core observation is the desire for privacy and integrity-preservation of data which is a driver for proposing, and deploying blockchain-based solutions in sports. This is evident in another study where researchers introduced blockchain into IoT for preventing reliance on centralised servers so as to effectively protect internet data and provide information security [46].

To provide a snapshot of the past, present, and future of research regarding blockchain in sports, Figure 6 provides a thematic map. As per classifications of the state and projections of research, we summarize the trajectory to guide future researchers based on the four quadrants of the strategic thematic map evident in figure 3 [47]: (a) *Motor themes*: Themes that fall under the upper right quadrant are well-developed and relevant structuring themes of the research field. Privacy is the salient term in this quadrant. Privacy is a core component of every blockchain deployment (i.e. privacy-preserving blockchains). As such within the sports domain the integration of blockchain researchers believe trust and privacy issues with respect to distributed data storage can be curbed [37]. (b) *Niche themes*: Themes that are identified in the upper left quadrant are highly specialized and peripheral to the domain. Within this quadrant, “machine learning” is salient. Machine learning coupled with blockchain technology in sports can be used in predictive modelling and monitoring of athlete performance [35, 50]. Artificial Intelligence deployed in sports is on the rise, and blockchain will continue to play a critical complementary role in data transparency and decentralization of models. (c) *Emerging (declining) themes*: Themes located within the lower left quadrant have a low density (i.e. level of development) as well as low centrality (relevance degree). (d) *Basic themes*: Themes located in the lower right quadrant are important but are still being developed. It is evident that privacy is at the core of every blockchain in sports. Thus, we observe that research with regards to blockchain technology’s diffusion, integration and adoption in sports is not a stand-alone implementation, rather, it is aimed at working hand-in-hand with internet of things (IoT), sensory data, machine learning and artificial intelligence.

Table 1 Applications of Blockchain in Sports Contexts

Use Case	Sports Context	Description
Trading Cards	Basketball	With Hyperledger Fabric, researchers proposed a blockchain-based NBA (National Basketball Association) digital trading card management system that has anti-counterfeiting traceability [30].
Fan Tokens (Sports Marketing)	Football	A growing aspect in the sports-entertainment industry is the rise in fan tokens where sports teams provide means for supporters to purchase virtual tokens that serve as an investment as well as access to exclusive offers. This study highlighted two popular tokens: Chiliz, and Socios [31]. Another study highlighted that governance tokens foster fan engagement through integrating fans into the decision-making processes thereby disrupting value co-creation within the sport marketing ecosystem [32].

Use Case	Sports Context	Description
Injury Life-Cycle Management	Football	Researchers used blockchain coupled with machine learning for gathering, storing, cleaning (pre-processing), mining and visualising the data of injuries of football players [33].
Management of Sports Rehabilitation Injury	All Sports	A study combined internet of things (IoT), blockchain technology, and neural networks for rehabilitation management purposes with the fusion of performance, biometric and other relevant data due to blockchain's tamper-resistance and unchangeability [34].
Sports Fitness Management	All Sports	<p>Researchers combined IoT and blockchain for the collection of real-time fitness signals via IoT sensors and the transmission of the data using blockchain technology [35].</p> <p>Another study delved into the integration of IoT and blockchain for fitness management of college sports athletes [36].</p> <p>Research focused on measuring and collecting health and exercise information of athletes for a real-time dynamic sports and fitness management technology model. The goal was to ensure the improvement of the integrity of the sports industry in China [37].</p> <p>To build a system for sports training assistance (running training auxiliary technology), another study combined wireless sensing technology and blockchain [38].</p>
Sustainable Sports Funding	All Sports	<p>Ensuring transparency in sustainable funding of sports subsidies in Slovakia at all levels (local, regional, and national levels) [39].</p> <p>Another study demonstrated that with respect to investment projects, blockchain technology is required for developing financial performance (for the context of the Kingdom of Saudi Arabia) [40].</p> <p>For Chinese sports clubs, research delved into the combination of blockchain technology and financing professional sports clubs through the introduction of smart contracts that can reduce financing costs, improve information transmission efficiency and reduce data storage risks [41].</p>
Mental Health Monitoring	All Sports	In a bid to develop a real-time monitoring system for the management of mental health of college students, researchers proposed a system based on blockchain technology [42].
Doping Control	All Sports	In accordance with the World Anti-Doping Agency (WADA) guidelines, researchers proposed developing a decentralised data governance model (at a multi-organizational level) coupled with a blockchain-based design (Hyperledger Fabric) for sensitive data-sharing within the anti-doping ecosystem [43].
Transparent Player Transfer Market	Football	To curb the irregularities and illegal transactions within the football transfer market, this study proposed Locality-Sensitive Hashing (LSH) coupled with blockchain technology in player transfer activities [44].

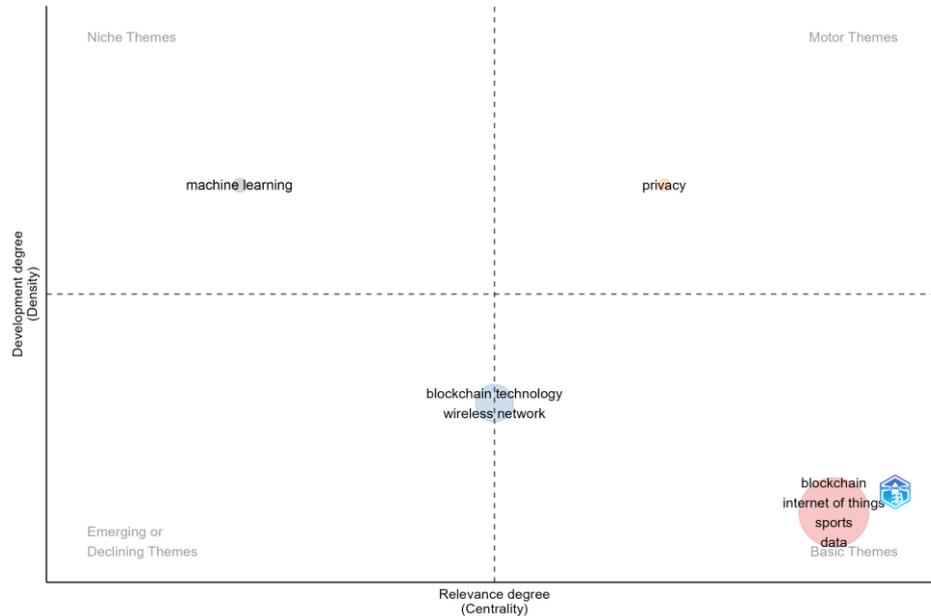


Fig. 6 Thematic Map (Research on Blockchain in Sports) -
(Source: Analytics from Bibliometrix)

Based on the thematic map from figure 6 where we observe the value of blockchain in sports is generated from its ability to be deployed with other modern technologies such as IoT, data (big data), as well as concepts such as privacy-by-design [51], our research draws on information systems theory known as Value Theory to propose a value-based framework for researchers and practitioners. Value theory holds the position that humans value a thing or an object based on its capacity to satisfy a desired need [52]. Value theory is linked with system usability and system acceptance within the information systems research domain [53]. Blockchain's value is evident in its ability to preserve privacy, eliminate fraudulent transactions, and encourage interoperability and decentralization of data across different stakeholders. As such, its value is a driving factor for adoption and integration in any given sports domain. In addition, the concept of value-generation based on the value theory is evident in results from Table 1 where we outlined the applications of blockchain technology in sports. These are a basis for proposing a value-generation framework which will serve as a reference point for experts, practitioners and researchers.

Figure 7 illustrates a framework we proposed to guide experts in the sports and blockchain domains with respect to utilizing blockchain as a basis for value generation, together with digital technologies and data-centric models. There must be seamless privacy-enforcing interoperability between the digital technology, data, and blockchain of choice and this can be achieved with APIs (application programming interface). Value in this context can be seen as the positive benefits derived from integrating blockchain into sports domains. The value of blockchain in sports will be actualized when researchers, startups, policy experts, decision-

makers across all sports domains and blockchain developers begin to leverage blockchain hand-in-hand with other digital innovations.

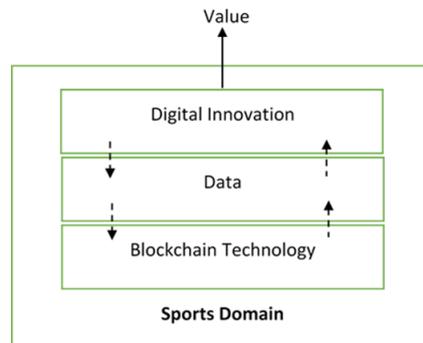


Fig. 7 Value-Generation Framework for Blockchain Technology in Sports -
(Source: Analytics from Bibliometrix)

5. CONCLUSION

Blockchain technology is currently undergoing a phase of value identification in the lifecycle of technological innovation. The sports domain is known for adopting digital transformation at a steady rate and as such this article delved into providing an overview on blockchain in sports. As a digital technological innovation in more recent times, blockchain has primarily been associated with cryptocurrency and majority of individuals have little insight of its use cases in other domains of discourse apart from the FinTech world. This article sheds light on the research conducted with regards to blockchain in sports and provides a snapshot for future researchers as well as practitioners and entrepreneurs to explore and build novel use cases. We observe that with respect to blockchain in sports, blockchain technology works hand-in-hand with other innovative technologies in order to maximize its value. In light of this observation, we designed a framework to guide experts when building. Thus, our research contributes to theory and practice. With respect to limitations, the number of articles used in the study can be expanded by including other research databases in future research. We also recommend future researchers to adopt the proposed framework in empirical studies to evaluate the effect of coupling digital technological innovation and blockchain technology on various sports domains.

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