



The potential of blockchain technologies for digital marketing – A critical assessment

Michail Vafeias¹, Nektarios Sartzetakis²

¹s & A Nemo Online Holding Ltd., Head Researcher, Korinthos, Greece

²s & A Nemo Online Holding Ltd., Supervising Researcher, Korinthos, Greece

ARTICLE INFO

Article history:

Received Jul 8, 2023

Revised Jul 24, 2023

Accepted Sep 26, 2023

Keywords:

Ad fraud;
Blockchain;
Digital Advertising;
Digital Marketing;
Distributed ledger;
technologies.

ABSTRACT

Blockchain is an emerging technology that is already finding applications in various sectors of economy, governance and trade, due to its attractive features of transparency and auditability. Digital marketing and advertising, i.e., the promotion of goods and services via digital media is currently a multibillion-dollar market with an increasing growth rate and crucial to the global economy. The potential of blockchain technologies for digital marketing applications has been recognized the last few years by both researchers and practitioners in this sector but, at the same time, large scale commercial applications have yet to be developed. This review, after briefly addressing the major challenges of the digital marketing ecosystem and the fundamental components of blockchain technologies, critically reviews academic works published the last 5 years in this field and highlights the current status, research topics and frameworks suggested. Moreover, the review addresses the main barriers to implementation of blockchain to large scale adoption in the digital marketing and advertising sector.

This is an open access article under the [CC BY-NC](https://creativecommons.org/licenses/by-nc/4.0/) license.



Corresponding Author:

Michail Vafeias,
S & A Nemo Online Holding Ltd.,
Head Researcher,
Apostolou Pavlou 33, Korinth, 201 31, Greece,
Email: michalisv@nemo.services

INTRODUCTION

Blockchain technologies (BT) were originally developed for supporting the Bitcoin cryptocurrency, which was implemented in 2009 (Monrat et al., 2019; Nakamoto, 2008). As implied by its name, the term is meant to describe a continuous chain of blocks (or packets of data) connected to each other that record transactions being executed in a decentralized network of peer nodes. All computers participating in the network have access to it and record transaction and communication data, each keeping a copy of the record file (transaction ledger), which ensures the security and transparency of transactions (public ledger) (Gorkhali et al., 2020; Lashkari & Musilek, 2021). The process of creating and preserving the file is defined and controlled by a set of rules called a consensus protocol (Lashkari & Musilek, 2021). The rules are set by the network participants and participation in the network automatically constitutes acceptance of them. Consequently, all transactions that

take place and are stored in this decentralized manner eliminates the need for validation and/or verification thereof by an intermediary entity.

The core features of BT, i.e., decentralization, auditability and transparency, make them attractive in other technological fields and/or industries where the need for transaction security and trust are important. Thus, it comes as no surprise that, since the implementation of Bitcoin, blockchain applications have begun to emerge in various fields such as financial and social services, risk management, healthcare facilities etc. (Monrat et al., 2019) In a recent report, PricewaterhouseCoopers (PwC) have estimated that BT can potentially to boost global GDP by US\$1.76 trillion until 2030 (Davies, 2020).

Marketing is another major GDP boosting sector. Global marketing spending in digital advertising channels has escalated the last few years to an estimated US\$567 billion in 2022 (Cramer-Flood, 2023). Its growth is expected to persist, mostly due to the emergence of mobile technologies, which have led to the increase of the penetration of internet in the global population (yearend estimates 2021) to a new maximum of 63% (ITU, 2021). As is the case with any rapidly evolving and fundamentally unregulated markets, quite a few challenges have surfaced. Most of them owed to the digital marketing ecosystem's convoluted and opaque supply chain (Gordon et al., 2020). These issues affect every member of the advertising chain: publishers, advertisers, and consumers. For instance, some of the most important consumer-specific challenges are malicious, offensive and/or misleading ads and harmful ad targeting. Advertiser related issues include ad fraud and brand safety risks (Adshead et al., 2020). The core features of BT mentioned earlier could potentially provide solutions to counter the effects of the challenges currently faced by the Digital Marketing industry. Moreover, beyond addressing the present challenges, BT offer opportunities for innovative potential that have already been recognized by different researchers and practitioners in the industry.

The purpose of this review is to critically assess the current and future potential of BT in the field of Digital Marketing, with a more detailed focus on the digital advertising segment of the ecosystem. As the intersection of BT and Digital Marketing is a field currently emerging, the body of research already published focuses either on the potential of blockchain technologies in a general manner or on suggestions and frameworks for future research. On the other hand, obstacles are ever present that have prevented, until now, large scale adoption and mass market applications of BT in digital marketing. No other review of this topic has included a discussion of these barriers to implementation, although from the perspective of real-world, large-scale applications, they are of even higher importance compared to the technological potential of blockchain. These obstacles will also be addressed in the course of this review, making the present work of significance to both scholars and practitioners in the field of digital marketing and advertising. Consequently, the present review is expected to aid researchers, marketing and management professionals and decision-makers in their assessment of BT in digital marketing. In addition to that, by highlighting the obstacles to implantation, this critical review can be helpful in orienting researchers in the field to new topics that will address the challenges reported.

The present article is comprised of the following sections. This brief introduction is followed by the background information section whose purpose is to set the conceptual foundations for the review. These information are presented in two subsections. The first will be focusing on the challenges that pervade the digital advertising ecosystem and threaten its growth. The second is on the fundamental features and terminology of BT, to aid the understanding of their disruptive potential in digital marketing. The next section focuses on presenting the literature review methodology, as well as its results and findings. It is comprised of (i) the critical review of the potential of BT to transform the digital marketing landscape and *modus operandi* and (ii) an account of the current major obstacles to implementation of BT in digital marketing. This article concludes with a brief summary the main findings of the previous sections and by drawing useful conclusions.

BACKGROUND OF THE STUDY

Challenges of the Digital Marketing Industry

Broadly defined, digital marketing is the promotion of products and services on the internet by use of digital media. Practically, the existence of a multitude digital media channels, services and products has created a much more complex ecosystem than the previous definition suggests (e.g. Search Engine Optimization (SEO), Pay-per-click (PPC), Social Media Marketing, Email marketing, Native advertising, Digital Video advertising etc.) In parallel, different forms and formats of advertisements have been developed for each channel, creating digital advertising markets with distinct features, allowing businesses to promote their goods with tailored messages, at specific locations and carefully selected audiences.

Side by side with the benefits of digital advertising markets also come the challenges. B.R. For instance, Gordon et al. have highlighted four major inefficiencies of the digital advertising industry: ad effect measurement, frictions between and within advertising channel members, ad blocking, and ad fraud (Gordon et al., 2020). Their review is comprehensive and there is no need to repeat their findings here. Nonetheless, the issues of ad fraud, ad blocking and of the complexity of the digital advertising landscape as a source of friction will be dealt with some more detail due to their importance in the subsequent sections of this article.

Ad fraud constitutes, probably, the most important challenge of the digital advertising industry. Put simply, the term refers to a group of practices that misrepresent advertising inventory or utilize machines (bots) to mimic human behaviour with the goal of “stealing” advertising budgets. Advertising fraud is extremely difficult to quantify and presumed to be widespread on the internet. For example, a recent report has estimated that about 14% of the global PPC ad spending is invalid and ad fraud schemes are the most likely explanation (Cavazos, 2020). An attempt to approach this phenomenon from the side of practitioners is that of K. R. Dörnyei, who performed an interview study among online marketing professionals to determine their position towards online ad fraud. Her results established that ad fraud is indeed characterized as a serious risk in their day-to-day activities from the professionals. Interestingly, the same professionals tolerate this issue due to low awareness and insufficient knowledge thereof among their clients. Effective detection of ad fraud is further enhanced by ineffective measurement systems and unrealistic expectations from the side of their customers (Dörnyei, 2021).

From a more technical standpoint, the current state of the usage and impact of bots in click fraud has been reviewed by Sadeghpour and Vlajic along with a listing of recent threat mitigation strategies that are available (Sadeghpour & Vlajic, 2021). Their review concludes that contemporary click-bots can replicate human-like interaction behaviors and, consequently, they are most likely undetected by traditional, interaction-based user behaviour analysis. Furthermore, the inefficacy of currently available solutions against constantly evolving and muting click bots in the real-world is highlighted. Finally, they suggest that the ad industry's lack of transparency and accessibility of information in the ecosystem is the most critical factor that inhibits the defense against ad fraud.

Interlinked with ad fraud is the challenge of ad-blocking. Currently, an estimated amount of 290 million active desktop users using ad blocking software solutions (2022 *PageFair Adblock Report*, 2022). The reason behind this increase can be traced to the dominance of personalized ad delivery with use of tracking cookies and to the overpopulation of ads, as a result of diminishing advertising profits from the side of publishers. Digital advertising is nowadays the industry of personalized ads. Tracking technologies allow the majority of advertising services to collect data about the users' online behaviour and habits, along with demographic or geolocation data. In turn, third-party data brokers aggregate data from several sources and sell them to marketers. N. H. Brinson et al. recently showed that it is exactly against this sort of personalized advertising that ad-blocking software users want to protect themselves against (Brinson et al., 2018). In addition to the

above, webpages overpopulated with ads are deteriorating the users' experience. B. Miroglio et al., showed in a relevant study that ad-blocking increases significantly active time spent browsing and number of webpages viewed (Miroglio et al., 2018). Besides the benefits to users, ad-blocking means revenue losses. For example it is reported that in 2016, estimated global loss from the use of ad-blocking was \$1.4 billion (Respati & Irwansyah, 2020).

Turning finally to the complexity of the digital advertising ecosystem, in its current state it includes countless advertisers, publishers, ad networks, agencies and affiliate networks. In addition to its ever-increasing size and the ecosystem also lacks a widely adopted ad targeting system for online audiences that would not compromise sensitive information and identity data of individual users. As a results, the industry has become dependent on the Meta/Google duopoly. The marketing and advertising services of these corporations account for more than half of the digital ad spend globally. Not surprisingly, they have more than once been accused of malpractices concerning data privacy and monopolistic behaviour (Colangelo & Maggolino, 2018). These players have lately been exploiting their privileged position and are trying to present themselves as de facto privacy regulators (Geradin et al., 2021). Moreover, middleware and intermediaries are absorbing increasing amounts of digital ad spend, pressuring the ad spending capacity of small and medium enterprises.

As a consequence of the aforementioned challenges, the digital advertising sector is in danger of reaching a point of devaluation, which could have dramatic effects for all actors in the value chain. This highlights the pressing need of the industry to invest in new technologies and frameworks that will secure brand safety, consumer privacy, effective ad measurement and transparency. Blockchain is one of the technologies with disruptive potential to achieve these goals.

Fundamentals of Blockchain technologies

It is beyond the scope of this review to perform an extensive introduction to the field of blockchain architecture. Excellent overviews of the subject can be found in literature (Dylan et al., 2018; Zheng & Lu, 2021; Zheng et al., 2017). In this section only some fundamental features of blockchain architecture are discussed that are important for the subsequent sections.

Transactions in blockchain

As described in the beginning of this review, Blockchain is a chain of blocks that store verified transactions in a public ledger. Blockchain operates in a decentralized network of peer nodes. Within the boundaries of this network the data and transactions carried out between nodes are registered and stored in packets (Blocks). The term "transaction" as used here is a data structure that represents transfer of digital assets between peers on the network. A blockchain network is distributed peer-to-peer (P2P), meaning that no one entity (person or computer) within the network is superior to another. All computers participating in the network have access to the blockchain (or ledger of transactions), each keeping a copy of the record file, which ensures security and transparency of transactions (Gorkhali et al., 2020; Lashkari & Musilek, 2021). The process of creating and preserving the file is defined and controlled by a set of rules called a consensus protocol (Lashkari & Musilek, 2021). The rules are set by the network participants and participation in the network automatically constitutes acceptance of them.

Each user (or node) in the blockchain owns a private key and public key. The private key is confidential and used to sign the transactions. Each transaction, before being registered in the Blockchain, is checked by the computers of the network based on the rules of the protocol. Once verified and approved, it is entered in the file according to the chronological order in which it was carried out. The file created and shared among a large number of users is encrypted and does not allow changing the records already registered in it, while the absence of a central administrator increases the reliability of the system, making it difficult to manipulate. In practice the log file acts

as an immutable record of transactions that does not require validation of the authenticity and integrity of the data by an external authority (Zheng & Lu, 2021).

Consensus approaches

The most common consensus approach is that of Proof of Work, used by Bitcoin, followed by Proof of Stake. They will be briefly described in this section.

Proof of Work (PoW): This approach is followed by Bitcoin. Transactions are grouped into a block. The hashing of the previous block acts as a unique identifier and is added to the current block, which connects all blocks together forming a chain. The internal consistency of transactions in each block can be easily verified by an honest client. For this reason, the nodes of a Blockchain network perform the Proof of Work algorithm to create a new block. This algorithm requires a node (also called miner) to pick a random number called a nonce, add it to the list of transactions that make up a block, hash the block and check whether the resulting hash starts with a specified number of zeros. If not, it picks a new random nonce number and tries again. The miner's computer processor will generate many hashes until it succeeds, making it a direct CPU-level problem. The Proof of Work algorithm is based on the principle that no node in the network should own more than 50% of the total computing power, as it will be able to effectively control the system (51% attack). When the network is managed by a large number of users, then this is almost impossible (Zheng et al., 2017).

Proof of Stake (PoS): The Proof of Stake algorithm replaces the competition of Proof of Work by randomly selecting participants, who will take part in the process of verifying transactions in a block and its subsequent entry into the Blockchain. In this particular algorithm, interested parties who want to participate in the validation process are required to "lock" a certain amount of coins in the network as their stake. A stakeholder of a given Blockchain is a person who holds some native coins of that Blockchain, and staking refers to a shareholder's ownership of such coins. The size of the stake determines the chances that a node will be selected as the next validator, i.e., the higher the stake, the higher the chances. In theory, validators with higher stakes are more likely to be chosen to validate their reputation. Compared to PoW, PoS is more efficient in terms of computing power required and effective. On the other hand, as the mining cost is nearly zero, the network can be easily attacked, especially if it's a public blockchain (Zheng et al., 2017).

Smart Contracts

Smart contracts are contracts written in coded form and executed by computers. Their execution being guaranteed by in blockchain P2P networks. Smart contracts represent the potential of developing peer-to-peer markets in the near future. A detailed description of the technological and technical properties of smart contracts has been performed by Z. Zheng et al. (Zheng et al., 2020), while a critical review of the main technological and legal issues raised during this early adoption period has been done by E. Mik (Mik, 2017).

In essence, a smart contract is a digital protocol whose purpose is to verify or facilitate the negotiation of an agreement. It contains rules that participants have agreed to adhere to in their transaction. When the predefined conditions of a smart contract are met, the contract is automatically activated. Consequently, smart contracts allow for trusted transactions to be performed without the need for a third party. Transactions are irreversible and simultaneously tracked. Blockchain platforms that support smart contracts are also referred to as programmable blockchains. (Oliva et al., 2020).

The principal advantage of smart contracts is the dramatic reduction in transaction costs. A smart contract defines the rights and obligations that the parties participating in a transaction agree to abide by. Compliance, monitoring and enforcement of each party's contractual right are handled by the blockchain network. In this way, it is possible to enter into contracts with members for whom there is no previous solvency information. Other attractive features include their continuous

operation and not imposing time or location-related availability restrictions. Smart contracts are self-verifying, self-executing and unbreakable. Their typical use cases are situations in which the parties wishing to enter into a contract do not know each other and do not necessarily trust each other. They can bypass intermediaries and through blockchain provide the required security.

Defining characteristics of blockchain technologies

As previously mentioned, research in BT expands beyond the cryptocurrency sector, and into diverse fields such as healthcare, identity management, asset tracking, law enforcement, insurance, energy etc. (Monrat et al., 2019) This wealth of potential applications is related to the attractive characteristics of BT, which are summarized in Table 1.

Table 1. Defining characteristics of BT. (Monrat et al., 2019; Zheng et al., 2017)

Characteristic	Description
Decentralization	<ul style="list-style-type: none"> No need for a trusted (central) entity. A transaction in the blockchain network can be conducted between any two peers (P2P) with the application of consensus algorithms that are used to maintain data consistency in distributed network. Server costs (including the development cost and the operation cost) are reduced and performance bottlenecks at the central server are avoided.
Persistency	<ul style="list-style-type: none"> With the infrastructure of blockchain truth can be measured and both producers and consumers can prove their data are authentic and not altered. It is almost impossible to manipulate or falsify data that are included in the blockchain, as such action will be detected by the network. Thus blockchain is defined as an immutable distributed ledger.
Anonymity	<ul style="list-style-type: none"> A user can participate and interact in the blockchain network with a randomly generated address or possess many addresses in the blockchain to avoid identification. Blockchain is built on a decentralized architecture and no authority is monitoring private information of users.
Auditability	<ul style="list-style-type: none"> Transactions taking place in the blockchain network are stored in the distributed ledger and validated by a unique digital timestamp. That makes auditing and tracing of previous records possible through any node in the network. For instance, in the case of Bitcoin, uses the Unspent Transaction Output (UTXO) model, that makes use of the property that any transaction has to refer to previous unspent transactions. When a transaction is recorded, the state of the unspent transactions switch to spent.

RESEARCH METHOD

BT and the emergence of corresponding applications in various business sectors, such as financing, supply chain management, insurance etc., has not gone unnoticed in the digital marketing and advertising sector. An increasing number of scholars and researchers have been active in this field the past few years, attempting to tackle a series of challenges that are specific to the nature of these sectors. In the next sections we attempt to critically assess works that address (a) the potential of BT in digital marketing and advertising and (b) the foreseen challenges and obstacles to implementing such technologies. For this review we searched the Google Scholar web search engine which indexes scholarly literature from a wide range of disciplines. The search was limited to articles published from the year 2018 and onwards. The search terms used were “blockchain” OR “blockchain technology” in combination with “digital marketing” OR “digital advertising”. From the search results obtained, the articles addressing issues (a) and (b) mentioned above were selected for the critical evaluation. The evaluation of each research article reviewed was based on the following criteria: (i) what are the domains/areas of digital marketing and/or advertising affected by BT, (ii) what features of BT do the authors recognize as the agents of disruption in those domains and (iii) do barriers to implementation exist and, if yes, what are these and how can they be addressed.

RESULTS & DISCUSSION

BT and the emergence of corresponding applications in various business sectors, such as financing, supply chain management, insurance etc., has not gone unnoticed in the digital marketing and advertising sector. An increasing number of scholars and researchers has been active in this field the past few years, attempting to tackle a series of challenges that are specific to the nature of these sectors. In the next sections we attempt to critically assess works that address (a) the potential of BT in digital marketing and advertising and (b) the foreseen challenges and obstacles to implementing such technologies.

Impact and potential of BT for digital marketing and advertising

The potential of BT to alter the landscape and modus operandi of the digital marketing and digital advertising industries has led many researchers to address these issues. In Table 2 some of the most comprehensive contributions in the field during the last 5 years are presented. The table summarizes the goals of each author, their methodological approach and the findings or claims they proceed to present resulting from their work.

Table 2. Critical review of contributions in the field of BT in digital marketing in the period 2018-2023.

Reference	Goals	Type of Publication	Findings or Claims
(Jain et al., 2021)	Highlight the blockchain-marketing integration and help future researchers by identifying the influential aspects of the published literature, future research streams and future research questions	Bibliometric Analysis and Review	<ul style="list-style-type: none"> The integration of blockchain with marketing has not been extensively explored in literature. The study identified influential co-authors, country, source, and keywords that will aid future researchers in the field. By analysis of citations the study identified five research clusters important for future research: Blockchain and Electronic Commerce, Blockchain and Marketing; Blockchain and Data; Blockchain and Data Analytics and Blockchain-Privacy and Security
(Wasiq et al., 2023)	Study, evaluation and summarizing existing literature to assess the current state of research and propose topics for future research in the adoption and application of BT in marketing	Bibliometric Analysis and Review	<ul style="list-style-type: none"> The study identified three emerging research streams: Blockchain marketing, Blockchain & Data and Blockchain data privacy & Security. Blockchain technology in marketing applications is a recently emerging field with most trends found in the period between 2017 to 2022. Designing and testing of blockchain-based marketing applications that can be applied to online businesses and especially the e-commerce sector appears as an important area for research.
(Rabby et al., 2022b)	An overview of BT and its applications in digital marketing to develop trust and transparency using big data. Also, whether there are insufficient hypotheses concerning the integration of blockchain and digital marketing and lay the foundations for future	Review Article	<ul style="list-style-type: none"> Blockchain-based solutions will apply more pressure on companies to deliver useful content and information across their networks. Businesses will be obligated to engage in more respectful and thorough interactions with their customers. Blockchain removes intermediaries, reduces cost, and enhances transparency and traceability. Blockchain is still in its infancy and mainstream adoption of Blockchain-based projects is still years away.

	academic research.		
(Abirou & Abghour, 2022)	Provide an understanding of blockchain and insights relevant to practitioners, illustrate up-to-date blockchain opportunities in digital marketing and how blockchain can help marketers improve their digital marketing strategy	Review Article	<ul style="list-style-type: none"> Blockchain provides new safe, smart, and trustful structures for storing data and reduces transaction fees. In large scale applications protecting customers' data privacy will be a significant challenge due to the diversity and complexity of digital markets. To address this issue, a blockchain-based governance approach and implications of digital companies for future research are needed.
(Bezovski et al., 2021)	Examination of the potential of BT to influence and even disrupt marketing different marketing functions (e.g. creation of new products and services, ensuring trust and transparency, disintermediation, privacy and data ownership, digital identity, customer relationship management, loyalty programs, advertising, fighting click fraud, supply chain management, etc.)	Review	<ul style="list-style-type: none"> The following features, areas and application of BT can change or disrupt digital marketing practices: (1) Trust, transparency and disintermediation, (2) Privacy, knowing the customers, ownership of data and personalization, (3) New products, services and business models, (4) Supply chain management, (5) Customer relationships, (6) Advertising click fraud. Blockchain applications for digital marketing are at an early development stage. More investigation and research are requested to assess which BT are able to be incorporated in digital markets in a reliable and sustainable way. Companies cannot afford to ignore the disruptive potential of the BT or they may lose their current positions and miss important business opportunities.
(Rejeb et al., 2020)	Assess how the core characteristics of BT enable functions and applications that can fundamentally change marketing strategies.	Review	<ul style="list-style-type: none"> The authors present six propositions that will guide future blockchain-related research in the area of marketings: (1) BT creates new market structures by fostering disintermediation, (2) BT helps to combat click fraud, (3) BT can help to reinforce consumers' trust in brands, (4) BT can enhance privacy protection (5) BT can empower digital marketing security, (6) BT can enable creative loyalty programs.
(Peres et al., 2023)	To assess the impact potential of blockchain technologies on different areas of marketing and provide suggestion for future topics that will further promote research and applications thereof in this field	Editorial	<ul style="list-style-type: none"> The potential of blockchain technologies for marketing applications lies in their core features of (a) being decentralized, (b) being distributed (P2P), (c) offering security and immutability, (d) being tokenizable, (e) being public and, at the same time, pseudonymous and (f) providing open-source logging
(Sihi, 2020)	Examination of current and potential uses of blockchain for marketing activities. Benefits and challenges in implementation are also discussed.		<ul style="list-style-type: none"> The author describes implementations and challenges in the following areas: (a) Blockchain in the Marketing Channel, where traceability of products in supply chains is already starting to be applied, (b) Blockchain to Reduce Advertising Fraud Blockchain technology can be used to create a direct link between an advertiser and publisher with smart contracts along each step of the network., (c) Blockchain for Incentivized Referrals - The

			<p>traceability of blockchain would presumably allow customer referrals to be traced back to the referring source. Smart contracts will enable automatic payment of referrers in digital currency when a referred business/person converges to a client status.</p>
(Garg et al., 2022)	To explore the evolution of blockchain and its potential impacts on digital marketing.	Review	<p>The author defined the following ways that BT can transform the digital marketing sector:</p> <ul style="list-style-type: none"> • Ensuring Data Privacy and fair use: Blockchain can help in controlling what data enters the ledger and ensures it cannot be abused. • Countering Ad Fraud: Blockchain can prevent duplicate and fake clicks. • Eliminating fake intermediaries: Blockchain with strong marketing policies based on smart contracts can ensure affiliate identity to avoid redundancy or abuse. • Accurate Analytics and performance measurement: Blockchain can facilitate audit process and verification of details related to advertising activities. • Credibility of Content: Blockchain can be used to identify fake content. • Transparency and Traceability in Digital Marketing: The fact that blockchain offers the characteristics of transparency and traceability enables customers to keep track of the brands, and if the brands are following their promises. • Smart Contract based operations: Using blockchain and smart contracts can allow a company to take the role of a trusted third party. • BT will become a critical component of industry 4.0. <ul style="list-style-type: none"> • BT can increase security, trust, transparency, confidence, and performance in the digital marketing environment, where data is the most important factor in determining the effectiveness of digital marketing efforts. • BT allows the collection of high-quality data without putting the data's integrity at risk. • Digital marketing and advertising systems powered by blockchain technology establish reliable and secure transactions while maintaining confidentiality.
(Rabby et al., 2022a)	Examine the effectiveness of digital marketing in the integration of industry 4.0 technologies	Review	<ul style="list-style-type: none"> • BT allows the collection of high-quality data without putting the data's integrity at risk. • Digital marketing and advertising systems powered by blockchain technology establish reliable and secure transactions while maintaining confidentiality.
(Pärssinen et al., 2018)	To address the issues of (a) scalability of blockchain technologies, (b) their energy efficiency in world of reducing CO2 emissions and (c) token volatility.	Review	<ul style="list-style-type: none"> • Wide implementation of blockchain technologies in digital advertising is not yet mature. To achieve the status of a trusted alternative in real-time bidding digital advertising applications, much more research and prototypes need to be developed.

From the data of the critical review presented in table 2 the following observations can be drawn: (a) The integration of BT in digital marketing and advertising has not been the subject of extensive literature research (Jain et al., 2021; Wasiq et al., 2023). On one side, this is an indication that the field is just starting to take shape and emerge. On the other hand, the complex nature of digital marketing ecosystem and the multitude of digital advertising channels with distinct market characteristics is an additional reason that explains the fragmented nature of research topics. (b) The majority of researchers in the field recognize the disruptive potential of BT, not only in marketing, but as a core feature of this technology. At the current stage of research, authors are

trying to establish research streams, frameworks and propositions to expand the scope of the field and the possible future applications. (c) There is no segment of the digital marketing and advertising sector that cannot be potentially affected or disrupted by BT, although large-scale commercial applications are not expected to become available in the coming years (Bezovski et al., 2021; Pärssinen et al., 2018; Rabby et al., 2022b). (d) Especially for the digital advertising sector the major challenges highlighted earlier in this research, namely ad fraud, ad measurement, removal of intermediaries and trust between parties of the ecosystem are all addressed and can potentially be solved in the future by the development of blockchain tools (Bezovski et al., 2021; Garg et al., 2022; Rabby et al., 2022b; Rejeb et al., 2020; Sihi, 2020). (e) Protection and integrity of customer and ad efficiency data, which will lead to renewed trust in the brands that adopt BT technologies, are also identified by researchers as features of these technologies that will heavily benefit the digital advertising ecosystem (Bezovski et al., 2021; Garg et al., 2022; Rabby et al., 2022a; Rejeb et al., 2020).

In the next section the most important obstacles to implementation of BT in digital marketing and advertising are discussed, based on the body of literature presents in Table 2.

Obstacles to implementation of blockchain technologies in digital marketing

The main obstacles to implementation of BT in digital marketing and advertising can be divided as follows:

Resistance to widespread adoption: This issue is related to both current market dynamics, lack of incentives and the inherent technical complexity of BT. D. Sihi points out that the emergence of effective blockchain applications in marketing, depends on the participation of all parties involved in the blockchain network, otherwise the information will be incomplete. Moreover, blockchain still bears a strong association with cryptocurrencies and given the open governmental and public criticism of these assets, implementation of blockchain will most likely be met with reluctance in many legacy organizations. This increases the proof of concept studies that will be necessary for different industries to invest in BT (Sihi, 2020). Following a similar line of thought F. Rabby et al. suggest that not all actors currently leading the sector have the incentives to use this technology. Certain digital advertising platforms do not profit unless they have the number of clicks and views they can provide and, as a consequence, do not have adequate incentives to adopt BT because of click fraud. Meta and Google are probably disinterested in any solutions that undercut their market position and as a result, they are likely to counter Blockchain solutions they perceive as a threat (Rabby et al., 2022b). Finally, M. Abirou et al. underlines the inherent complexity of BT and suggests that wider adoption digital ecosystems requires a targeted learning programs and blockchain awareness campaigns for individuals, using simple and suitable language (Abirou & Abghour, 2022).

New rules and regulations: Blockchain is built up on the concept of trust among the dispersed nodes of a P2P network which authenticate new transactions in blocks of data. As the number of organizations and/or individuals using blockchain increases, more formal rules of engagement may become necessary. This of course comes at the cost of trying to maintain a balance between stricter rules and the decentralized nature of blockchain that is valued by users (Sihi, 2020). In addition to the aforementioned concerns, A. Rejeb et al., at this stage of development blockchain is hampered by the lack of a suitable governance structure (Rejeb et al., 2020).

Limitations in scale: The study of M. Pärssinen et al. is the most comprehensive as far as technical limitations to the adoption of BT are concerned (Pärssinen et al., 2018). Considering the security of Bitcoin as benchmark for the adoption of BT outside the cryptocurrencies sector, they propose that alternative blockchains must first secure their network with equal hashing power, which is neither economic nor energy efficient. Due to the scarcity of data concerning the power consumption of alternative BT at a scale near Bitcoin, they proceeded to analyze the energy consumption of Bitcoin's PoW as a reference point.

According to the results of their study Bitcoin mining uses approximately 982 MWh/day (as of 2018). This is equal to an energy cost of US\$15 million which has to be paid in traditional currency. With the growth rate reported at the time of the study, Bitcoin mining amounted to a continuous energy consumption varying between the output of a small power plant and the total energy consumption of a small country, such as Denmark. The authors further report on a modelling tool deployed by the Long Future Foundation, showing that Bitcoin could in the future consume up to 60% of global energy production, or 13000 TWh. Even in their conservative scenario of a 5% year-on-year growth and with only 50% of the energy originating from the burning of fossil fuel, over 4000 kg of CO₂ emissions per mined Bitcoin is produced. In comparison, the average person creates roughly 5000 kg of CO₂ emissions per year. The technological advancements in chip making and hardware manufacturers suggest that Bitcoin miners are likely to become more than 3x times more efficient, but at the same period Bitcoin usage is expected to outgrow these technological innovations. According to J. Truby (2018), Bitcoin was never designed with consideration of the potential impacts of BT in the environment. Consequently, the leveraging of BT in digital marketing activities can cause undue environmental damage through high rates of electricity consumption and emissions, which might prevent organizations from adopting blockchain (Truby, 2018).

D. Sihi also reflected on the same issue of processing power and energy consumption of the block mining process (Sihi, 2020). If the same consensus algorithm is to be applied in digital advertising to tackle the challenges of ad fraud which require processing at the scale of milliseconds, the process needs to become more energy efficient otherwise the energy costs will be prohibitive to implementation. F. Rabby et al. reported that the current large scale BT application of Bitcoin can only handle megabytes (MB) of data and consensus algorithms are not scalable to the amount of data related with digital advertising transactions.

Some mitigation measures that are being studied is (a) the design of BT applications in a way where not all transaction data are processed and stored in the blockchain (off-chain solutions) and (b) use of private blockchains which limit the number of participants to the chain, thereby using less energy. Finally, the mining part of the data verification process has been removed from some private or permissioned blockchains. Nonetheless, these modifications require a tradeoff between BT being a truly public, decentralized technology to one that has a growing number of constraints.

CONCLUSION

Two were the main research goals of this review as set in the introduction. Firstly to assess the potential of BT in digital marketing and highlight the areas and sectors of this particular industry that can potentially be disrupted. In addition, to show that fields of potential disruption include the major challenges which the digital marketing ecosystem is currently trying to resolve. Secondly, to trace and examine what current research identifies as the major barriers to implementation of BT in digital marketing and advertising. This critical review has contributed to both of them.

Concerning the first research objective, researchers in the field recognize ad fraud, data transparency and credibility, removal of intermediaries and integrity of ad measurement as sectors of the digital marketing ecosystem that can benefit from the adoption of BT. Indeed, these are all challenging issues for the digital marketing ecosystem and the industry is looking for innovative solutions to them. Concerning the second research objective, several obstacles to large scale implementation of BT in digital marketing were identified. BT are limited by computing scale and the cost of energy demands to achieve the computation strength needed. In addition, BT are still largely unregulated and legal and/or governance efforts towards this end are needed. Finally, BT are still associated with Bitcoin and cryptocurrencies, a fact that inhibits their acceptance in more mainstream applications.

The major implications deriving from this critical review relate to the level of maturity of BT in digital marketing and the technical issues that need to be addressed. The general consensus is that, for all their disruptive potential, BT are still far from being able to provide commercial alternative solutions to the current scale that real-time bidding digital advertising tools are operating. Besides, the regulatory issues and its association with cryptocurrencies, the main reason for this lie in the engineering side of BT. As researchers in the field point out, the energy demands, CO₂ footprint and corresponding capital and operational costs of substituting the current state of the art technologies with BT is immense. At the same time, the time to complete advertising transactions in current digital advertising tools is the scale of seconds, a duration that current BT cannot achieve. Consequently, research in the field should be directed to addressing these issues.

The authors of this work identify the limited amount of published scientific work in the field of blockchain application in digital advertising as the main limitation of this study. The potential of BT in digital marketing and, in particular, in digital advertising is a research field still in its infancy. If one also considers the complexity of the digital advertising ecosystem with its millions of players (agencies, advertisers, publishers, mega-corporations, intermediaries etc.), it is possible that the future direction of research will head towards domain-specific application of BT, rather than integrated, generic solutions. Future work will focus on reviewing and assessing such domain-specific applications. The authors also expect that BT applications in digital advertising and marketing will enter the digital advertising market by such domain-specific application of limited-scale.

References

- 2022 PageFair Adblock Report. (2022). Blockthrough.com. Retrieved 22 May from
- Abirou, M., & Abghour, N. (2022). A Review of Blockchain and the Benefits for Digital Marketing-Related Applications of Blockchain Integration. In F. Saeed, T. Al-Hadhrami, E. Mohammed, & M. Al-Sarem, *Advances on Smart and Soft Computing* Singapore.
- Adshead, S., Chan, Y. S., Lavender, T., Wilkinson, L., & Schoentgen, A. (2020). *Mapping online advertising issues, and the industry and regulatory initiatives aimed at addressing them*. <https://www.gov.uk/government/publications/mapping-online-advertising-issues-and-the-industry-and-regulatory-initiatives-aimed-at-addressing-them>
- Bezovski, Z., Jovanov, T., & Temjanovski, R. (2021). The impact and the potential disruption of the blockchain technology on marketing. *Journal of Economics*, 6(1), 13-23.
- Brinson, N. H., Eastin, M. S., & Cicchirillo, V. J. (2018). Reactance to Personalization: Understanding the Drivers Behind the Growth of Ad Blocking. *Journal of Interactive Advertising*, 18(2), 136-147. <https://doi.org/10.1080/15252019.2018.1491350>
- Cavazos, R. (2020). *The Economic Cost of Invalid Clicks in Paid Search and Paid Social Campaigns*. U. o. Baltimore. <https://cdn2.hubspot.net/hubfs/5228455/UniBaltimore%20PPC%20Fraud-1.pdf>
- Colangelo, G., & Maggiolino, M. (2018). Data accumulation and the privacy-antitrust interface: insights from the Facebook case. *International Data Privacy Law*, 8(3), 224-239. <https://doi.org/10.1093/idpl/ipy018>
- Cramer-Flood, E. (2023). *Worldwide Digital Ad Spending 2023*. eMarketer. Retrieved 22 May from <https://www.insiderintelligence.com/content/worldwide-digital-ad-spending-2023>
- Davies, S. (2020). *Time for trust, The trillion-dollar reasons to rethink blockchain*. PwC. <https://www.pwc.com/gx/en/industries/technology/publications/blockchain-report-transform-business-economy.html>
- Dörnyei, K. R. (2021). Marketing Professionals' Views on Online Advertising Fraud. *Journal of Current Issues & Research in Advertising*, 42(2), 156-174. <https://doi.org/10.1080/10641734.2020.1737276>
- Dylan, Y., Peter, M., Nik, R., & Karen, S. (2018). Blockchain Technology Overview. In: NIST Interagency/Internal Report (NISTIR), National Institute of Standards and Technology, Gaithersburg, MD.
- Garg, S., Gupta, S., & Gupta, B. (2022). Impacts of Blockchain on Digital Marketing. In A. K. Nagar, D. S. Jat, G. Marín-Raventós, & D. K. Mishra, *Intelligent Sustainable Systems* Singapore.

- Geradin, D., Katsifis, D., & Karanikioti, T. (2021). Google as a de facto privacy regulator: analysing the Privacy Sandbox from an antitrust perspective. *European Competition Journal*, 17(3), 617-681. <https://doi.org/10.1080/17441056.2021.1930450>
- Gordon, B. R., Jerath, K., Katona, Z., Narayanan, S., Shin, J., & Wilbur, K. C. (2020). Inefficiencies in Digital Advertising Markets. *Journal of Marketing*, 85(1), 7-25. <https://doi.org/10.1177/0022242920913236>
- Gorkhali, A., Li, L., & Shrestha, A. (2020). Blockchain: a literature review. *Journal of Management Analytics*, 7(No. 3), 321-343.
- ITU. (2021). *Individuals using the Internet (% of population)*. International Telecommunication Union. Retrieved 22 May from <https://data.worldbank.org/indicator/IT.NET.USER.ZS>
- Jain, D., Dash, M. K., Kumar, A., & Luthra, S. (2021). How is Blockchain used in marketing: A review and research agenda. *International Journal of Information Management Data Insights*, 1(2), 100044. <https://doi.org/https://doi.org/10.1016/j.ijime.2021.100044>
- Lashkari, B., & Musilek, P. (2021). A Comprehensive Review of Blockchain Consensus Mechanisms. *IEEE Access (Volume: 9)*, 43620 - 43652.
- Mik, E. (2017). Smart contracts: terminology, technical limitations and real world complexity. *Law, Innovation and Technology*, 9(2), 296-300.
- Miroglio, B., Zeber, D., Kaye, J., & Weiss, R. (2018). *The Effect of Ad Blocking on User Engagement with the Web* Proceedings of the 2018 World Wide Web Conference, Lyon, France. <https://doi.org/10.1145/3178876.3186162>
- Monrat, A. A., Schelén, O., & Andersson, K. (2019). A Survey of Blockchain From the Perspectives of Applications, Challenges, and Opportunities. *IEEE Access*, 7, 117134-117151. <https://doi.org/10.1109/ACCESS.2019.2936094>
- Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. *Decentralized business review*, 21260.
- Oliva, G. A., Hassan, A. E., & Jiang, Z. M. (2020). An exploratory study of smart contracts in the Ethereum blockchain platform. *Empirical Software Engineering*, 25, 1864-1904
- Pärssinen, M., Kotila, M., Rumin, R. C., Phansalkar, A., & Manner, J. (2018). Is Blockchain Ready to Revolutionize Online Advertising? *IEEE Access*, 6, 54884-54899. <https://doi.org/10.1109/ACCESS.2018.2872694>
- Peres, R., Schreier, M., Schweidel, D. A., & Sorescu, A. (2023). Blockchain meets marketing: Opportunities, threats, and avenues for future research. *International Journal of Research in Marketing*, 40(1), 1-11. <https://doi.org/https://doi.org/10.1016/j.ijresmar.2022.08.001>
- Rabby, F., Chimhundu, R., & Hassan, R. (2022a). Blockchain-Enabled Trust Management for Digital Marketing in the Industry 4.0 Era. In Y. Maleh, L. a. Tawalbeh, S. Motahhir, & A. S. Hafid (Eds.), *Advances in Blockchain Technology for Cyber Physical Systems* (pp. 303-321). Springer International Publishing. https://doi.org/10.1007/978-3-030-93646-4_14
- Rabby, F., Chimhundu, R., & Hassan, R. (2022b). Blockchain Technology Transforms Digital Marketing by Growing Consumer Trust. In S. M. Idrees & M. Nowostawski (Eds.), *Transformations Through Blockchain Technology : The New Digital Revolution* (pp. 265-289). Springer International Publishing. https://doi.org/10.1007/978-3-030-93344-9_12
- Rejeb, A., Keogh, J. G., & Treiblmaier, H. (2020). How Blockchain Technology Can Benefit Marketing: Six Pending Research Areas [Review]. *Frontiers in Blockchain*, 3. <https://doi.org/10.3389/fbloc.2020.00003>
- Respati, R. E., & Irwansyah, I. (2020, 6-7 November 2019). *Ad-Blocking Threats on Online Advertising* Proceedings of 3rd International Conference on Strategic and Global Studies, ICSGS 2019, Sari Pacific, Jakarta, Indonesia.
- Sadeghpour, S., & Vljajic, N. (2021). Click Fraud in Digital Advertising: A Comprehensive Survey. *Computers*, 10(12), 164. <https://www.mdpi.com/2073-431X/10/12/164>
- Sihi, D. (2020). Impacts of Blockchain Technology in Marketing. In F. J. Martínez-López & S. D'Alessandro, *Advances in Digital Marketing and eCommerce Cham*.
- Truby, J. (2018). Decarbonizing Bitcoin: Law and policy choices for reducing the energy consumption of Blockchain technologies and digital currencies. *Energy Research & Social Science*, 44, 399-410. <https://doi.org/https://doi.org/10.1016/j.erss.2018.06.009>
- Wasiq, M., Bashar, A., Akmal, S., Rabbani, M. R., Saifi, M. A., Nawaz, N., & Nasef, Y. T. (2023). Adoption and Applications of Blockchain Technology in Marketing: A Retrospective Overview and Bibliometric Analysis. *Sustainability*, 15(4), 3279. <https://www.mdpi.com/2071-1050/15/4/3279>

- Zheng, X. R., & Lu, Y. (2021). Blockchain technology – recent research and future trend. *Enterprise Information Systems*.
- Zheng, Z., Xie, S., Dai, H.-N., Chen, W., Chen, X., Weng, J., & Imran, M. (2020). An overview on smart contracts: Challenges, advances and platforms. *Future Generation Computer Systems*, 105, 475-491.
- Zheng, Z., Xie, S., Dai, H., Chen, X., & Wang, H. (2017, 25-30 June 2017). An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends. 2017 IEEE International Congress on Big Data (BigData Congress),