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Enhancing Digital Advertising with Blockchain Technology

Valerio Stallone, Martin Wetzels, Dominik Mahr, and Michael Klaas

Abstract

The increasing popularity of blockchain technology (BCT) has spurred interest in its potential to rejuvenate the digital advertising ecosystem. Due to its transparency, decentralization, and immutability, BCT offers the potential for customer-oriented, secure, and open platforms that might improve interactions between consumers and businesses. This article investigates applications of BCT in digital advertising and develops an integrative framework to classify innovations at this intersection. With a systematic literature review and Delphi study, the authors examine ten relevant use cases and compile qualitative and quantitative data on the expected probability of realization, expected impact on the industry, desirability of occurrence, and market establishment duration. The results reveal organizational activity theory–informed areas of innovation and provide useful insights for managers, researchers, and policy makers. Managers should focus on contextual innovations such as rewarding web users for web interactions, rewarding content creators for their contributions, and ensuring user data security as the most relevant potential applications. Boundary innovations require a better understanding before deploying solutions aimed at increasing advertising supply chain transparency, mitigating fraud, and verifying content. For domain-based innovation areas, researchers must rethink their foundations. Finally, the authors propose a detailed research agenda.

Keywords

online advertising, technology and innovations, blockchain technology, organizational activity system

Blockchain technology (BCT) promises solutions to various issues currently observed in digital advertising, such as data security and trust, incentivizing participation, and securing transactions between all stakeholders in the ecosystem (Yun and Strycharz 2022). It represents transparency, decentralization, and unforgeability, and can record data from different sources in a distributed database, reduce the need for intermediaries, verify transaction sources, make the level of permissions disclosure more flexible, and quantify intangible assets (Peres et al. 2023). As such, BCT has the potential to improve customer-centric, secure, and open innovations for improved exchanges throughout the value creation and capture processes among the key stakeholders—namely, consumers and businesses (Ghose 2018; Gleim and Stevens 2021; Harvey, Moorman, and Toledo 2018; Rangaswamy et al. 2020; Stallone, Wetzels, and Klaas 2021). Organizations should use such digital transformation technologies to strengthen relationships between stakeholders (Gleim and Stevens 2021), build trust among stakeholders (Nigam et al. 2022), and increase the intensity of value exchange (Joo et al. 2023). Digital advertising is one potential way to create value in a consumer–business relationship (Hayes et al. 2021), and its ecosystem consists of users, publishers, advertisers, and intermediaries (Gordon et al. 2021). Digital advertising can be improved through the application of BCT (Colicev 2023; Joo et al. 2023; Malik et al. 2023; Marthews and Tucker 2023; Peres et al. 2023). To realize the potential benefits of BCT, however, innovations in different activities are needed. Our contribution, the first of its kind, offers an integrative framework to classify BCT innovations in the interconnected digital advertising ecosystem (DAE). Our approach is informed by organizational activity theory (OAT) and considers the need to be comprehensible and flexible.

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Table 1. BCT Application in Digital Advertising: Academic Contribution Differentiation.

Knowledge Management Category (Gera 2012)	Type of Conceptual Contribution (MacInnis 2011)	Authors	Theoretical Contribution		Empirical Contribution		
			OAT	Innovations	SLR	SUCR	Survey of UC
Knowledge creation (research agenda proposition)	Envisioning	Peres et al. (2023)	—	X	—	—	—
		Pärssinen et al. (2018)	—	X	—	—	X
Knowledge diffusion (application guide)	Explicating	Joo et al. (2023)	—	X	—	X	—
		Tan and Saraniemi (2022)	—	X	—	—	X
		Xin and Zhang (2020)	—	X	—	—	X
Knowledge utilization (application investigation)		Lax and Russo (2019)	—	X	—	—	X
Knowledge adoption (solution identification)	Relating	Current study	X	X	X	X	X

Notes: Innovations = contextual, boundary, and domain; SLR = systematic literature review; SUCR = systematic use case retrieval; survey of UC = expert- or experiment-informed survey of use cases.

OAT provides a framework for analyzing the activities and interactions that take place within interconnected organizations (Blackler, Crump, and McDonald 2000). It emphasizes the importance of understanding how activities are coordinated and how they contribute to the overall functioning of the organization (Blackler, Crump, and McDonald 2000). Our article expands the scope and applicability of OAT twofold. First, it helps understand the complex relationships, activities, and dynamics within the DAE. We take what is known and has been theorized about the DAE as a network of interconnected stakeholders and activities and transform it into something entirely new. OAT, with its emphasis on collective formations of activities, higher-order functions, and mediating factors, provides a robust framework to analyze and comprehend the interactions among various stakeholders in the DAE, relating and adopting existent knowledge (Gera 2012; MacInnis 2011). Additionally, we extend OAT's theoretical foundation by incorporating the decentralized, transparent, and immutable nature of BCT, which influences the activities, decision-making processes, and innovation dynamics within the DAE. Through this integration, we deepen our understanding of how organizations within the DAE navigate and adapt to the evolving digital advertising landscape, allowing us to capture the complex relationships, engagements, and interactions within the DAE and providing a more in-depth understanding of how BCT can address challenges and gaps and help identify specific solutions. In exploring BCT applications within the DAE, our research enhances the overall comprehension of how this nascent technology can be employed to create secure, customer-centric, and open platforms. Table 1 shows how we differentiate the current study from those investigating comparable use cases of BCT applications in digital advertising.

To date, only a few scholars have investigated contextual, boundary and domain-based innovations in BCT-enabled digital advertising. Scholars have provided (1) research agenda propositions (knowledge creation) pertaining to why it is necessary to look for answers to questions about the application of BCT in the DAE and the advantages such answers could provide (Pärssinen et al. 2018; Peres et al. 2023), (2) application guides (knowledge diffusion) describing what the entity of the answers BCT could deliver to DAE should be (Joo et al. 2023; Tan and Saraniemi 2022; Xin and Zhang 2020), and (3) application investigations (knowledge utilization) regarding how to design BCT to address advertising issues (Lax and Russo 2019). To develop a better understanding of the application of BCT in digital advertising (ABA) and to make the findings more transformable, assimilable, and internalizable, a richer and more advanced combination of theory and practice in an empirical way is needed (knowledge adoption) to help identify solution fields that both accommodate extant knowledge and reveal novel insights (Gera 2012; MacInnis 2011).

Accordingly, we propose the following research question: *How will BCT affect the future of digital advertising and its ecosystem of stakeholders?* By addressing this question, we contribute to the current body of knowledge in the fields of advertising technology (adtech), BCT, and activity theory by conceptualizing ABA through the lens of OAT. We transform, assimilate, and internalize knowledge by gathering expert perspectives on concrete occurrences of use cases of ABA among innovation clusters informed by organizational activity systems and by stating the expected probability of realization, expected impact on the industry, desirability by the communities within the ecosystem, and the market establishment duration of ABA. This comprehensive analysis helps stakeholders make better-informed decisions about the adoption of ABA and contributes to a deeper understanding of their practical implications.

We begin with a discussion of the organizational activity system with respect to digital advertising and introduce the use cases we identified in a systematic literature review of top marketing journals. We then explain why we opted for a classic Delphi method and discuss our procedures for participant selection and solicitation. Subsequently, we analyze the data collected through this method. After discussing the results, we aggregate and synthesize the findings into a meticulously structured and detailed research agenda. We conclude with a review of our findings and the limitations of our research.

Theoretical Integration

OAT emphasizes the importance of innovation and adaptation within organizations as they respond to changes in their environment (Blackler, Crump, and McDonald 2000). This focus aligns with our study's objective of investigating BCT applications in digital advertising, in that BCT innovations have the potential to address many challenges in the DAE, such as transparency, decentralization, and immutability. In this section, and in line with MacInnis's (2011) typology, our primary conceptual goal is to relate and integrate the findings to provide a holistic understanding of the DAE. We identify key stakeholders and their roles within the DAE and elucidate the intricate relationships and interactions among them. This approach enables us to recognize potential areas for innovation within the DAE, while examining how BCT innovations can address specific challenges and gaps. Ultimately, in this section we aim to synthesize, amalgamate, and harmonize understanding of the DAE and its various components to foster a unified perspective that transcends the limitations of individual constituent parts by delivering the aforementioned integrative framework.

Organizational Activity Systems in Digital Advertising

The activities of digital advertising—implying engagement by an acting entity to achieve a certain goal or objective (Engeström 2015)—require a network of stakeholders consisting of advertisers, publishers, intermediaries, regulators, and users. In the DAE, organizations such as advertisers and publishers function as knowledge-based systems with indeterminate, emergent, distributed, and decentralized knowledge (Tsoukas 1996). This perspective highlights the fluidity of their knowledge and the dynamic interplay among various stakeholders as they adapt to the evolving DAE landscape. As such, an organizational activity system is a collective formation of activities with a complex mediational structure (Engeström 2015). OAT describes the functions that arise from the relationships between neighboring nodes of the system and can be used to examine the partnerships of the different stakeholders in the DAE.

OAT can help shed light on the complex relationships and activities—namely, execution, distribution, and collaboration—within the DAE, which are mediated by domain, contextual, and boundary innovations (Ciuchita et al. 2023). Execution creates artifacts according to the needs or desired emerging collective object of the activity system. Collaboration refers to the interactions among community members. Distribution divides activities and outcomes according to the social laws of the community. In summary, OAT provides the foundation for our integrative framework and is particularly relevant to our research objective because it incorporates all the relevant factors DAE actors interact with; the relationships among them through higher-order functions (Ciuchita et al. 2023); and the concepts of boundary, contextual, and domain innovations as mediating factors that help explain how organizations adapt and evolve in response to changes in their environment. Figure 1 offers support for our view of the DAE, its actors, and the relationships among them through the aforementioned functions and the mediating factors:

- Brands (advertisers; community of activity) execute activity by targeting users to reach their activity's objective (users' attention; emerging collective object of activity).
- Brands achieve the desired transformation of the activity (user engagement; desired outcomes) in collaboration with partners (publishers, intermediaries, and policy makers; related communities of activity).
- Publishers distribute the activity in various channels (e.g., social media, mobile devices, search engines) (Deighton 1997; Gusic and Stallone 2020; Hayes et al. 2021; Tauro, Panniello, and Pellegrino 2021).

More decentralized and open platforms for achieving the collective objective of activities could help promote competition and prevent any single organization from gaining too much control over the ecosystem (Rangaswamy et al. 2020). In line with our overarching theoretical goal of advancing understanding related to BCT's potential in reshaping the DAE through the lens of OAT, the following section explores the different types of innovations that serve as mediating factors in the activities between actors in the system.

Integrating BCT, DAE, and OAT

In this section, we synchronize the interplay among our key concepts. We demonstrate that if we examine BCT—with its decentralized, transparent, and immutable nature—through the lens of the OAT framework, it both does and does not fit the purpose of reshaping the future of the DAE, facilitated by the mediating effect of innovations.

Decentrality. The integration of BCT, DAE, and OAT emphasizes the distributed nature of the DAE. BCT's decentralized architecture aligns with the concept of organizations as knowledge-based systems with decentralized knowledge. This alignment enables a better understanding of how different stakeholders in the DAE interact and collaborate, fostering an environment in which innovations can emerge organically without central control (Peres et al. 2023). Moreover, OAT helps contextualize these decentralized processes, providing insights into how organizations navigate and adapt to the DAE's complex, interconnected landscape (Gordon et al. 2021).

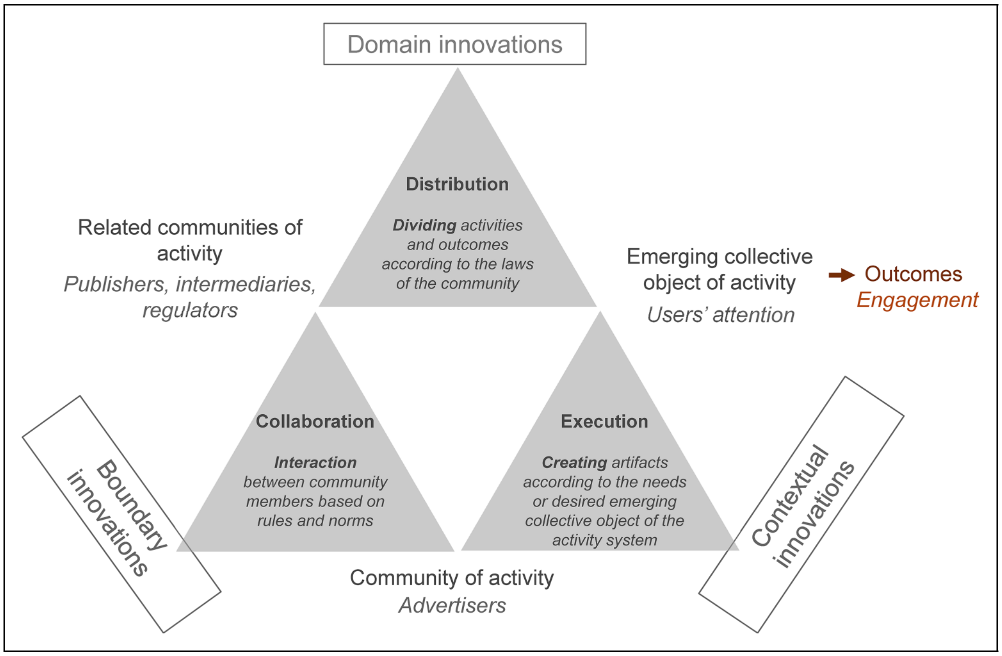

Figure 1. Organizational Activity System in Digital Advertising.
Notes: The graphic is based on Blackler, Crump, and McDonald (2000) and Ciuchita et al. (2023).

However, a decentrality focus might not fully capture some of the more centralized aspects of the DAE. For example, the dominance of a few major players in the digital advertising industry could create power imbalances and monopolistic tendencies that challenge the decentralized nature of the system (U.S. Justice Department 2023). In such cases, the integration of BCT, DAE, and OAT might not adequately address these centralized aspects and their implications for the overall functioning and innovation within the DAE. In addition, decentrality may lead to fragmentation and inefficiencies, making it challenging to develop and implement cohesive strategies or policies in the DAE (Joo et al. 2023).

Transparency. Open and accessible information within the DAE is crucial for the organizational system. Because it is known for its transparent and traceable nature, BCT can provide insights into the actions and decisions of various stakeholders, fostering trust and accountability in the DAE (Tan and Saraniemi 2022). Moreover, OAT helps elucidate how organizations navigate this transparent environment, providing a clearer understanding of the underlying processes, motivations, and potential areas for improvement.

However, the focus on transparency might not sufficiently address all the complexities and challenges within the DAE. Although transparency is generally desirable, it can lead to unintended consequences, such as privacy concerns, information overload, or misuse of data (Joo et al. 2023; Tan and Saraniemi 2022). In such cases, the integration of BCT, DAE, and OAT might not provide adequate insights into how to balance transparency with other important considerations, such as privacy and data security.

Immutability. The integration of BCT, the DAE, and OAT fits the purpose because it emphasizes the importance of secure, tamper-proof data in the DAE. BCT's inherent immutability ensures that information within the system cannot be altered or manipulated, thus fostering trust and confidence among stakeholders (Lax and Russo 2019; Pärssinen et al. 2018). By incorporating OAT, we can better understand how organizations operate and adapt within this immutable environment, elucidating the ways in which secure, unalterable data can improve decision making, collaboration, and overall efficiency within the DAE.

However, immutability can be a double-edged sword; it may prevent necessary adjustments or corrections to data or processes within the DAE. If an error occurs or new information becomes available, the inability to modify the immutable data could lead to suboptimal outcomes or perpetuate inaccuracies (Lax and Russo 2019; Pärssinen et al. 2018). In such cases, the integration of BCT, the DAE, and OAT might not adequately address the need for flexibility and adaptability within the system. In addition, despite the inherent immutability of BCT, if actors find ways to exploit the system or bypass its safeguards, it poses challenges to the overall security and reliability of the DAE.

Innovation areas. OAT highlights the importance of innovation and adaptation in response to changes in the environment. BCT's versatile nature allows for the development of novel solutions that address various challenges and gaps in the DAE. These innovative applications can improve efficiency, transparency, and user experiences in the DAE. By considering boundary, contextual, and domain innovations as mediating factors in OAT, we can explore how BCT applications can address specific challenges in the DAE.

Boundary innovations encompass alterations in the methods by which advertisers and publishers buy and sell advertising, with subsequent impacts on ad execution (Lee and Cho 2020). These innovations transform the DAE's processes and pave the way for more efficient and transparent transactions that harmonize the various components. Although BCT can improve the execution of advertising by streamlining the buying and selling process, enabling smart contracts, and automating payment settlements, which enhances efficiency and transparency in the ecosystem, the integration may not capture some centralized aspects such as power imbalances or monopolistic tendencies.

Contextual innovations involve changes in the knowledge or expertise that advertisers and publishers possess about users or other key contributors to associated communities of activity. BCT can enhance user data security and privacy, allowing advertisers to better understand their target audience and deliver ads more effectively. BCT can also be used to reward users for their web interactions and content creators for their contributions, fostering a more user-centric ecosystem. The integration may not provide adequate insights into balancing transparency with user data security.

Domain innovations in the DAE entail modifications to the channel environment in which the DAE operates, by "expanding the comprehensive meaning of digital advertising" (Lee and Cho 2020, p. 335). BCT can support the development of new advertising channels and platforms, leveraging the decentralized and open nature of the technology to create alternative models that challenge existing monopolies and encourage innovation. Despite the inherent immutability of BCT, there may be instances in which actors find ways to exploit the system or bypass its safeguards, thus posing challenges to the overall security and reliability of the DAE.

In summary, we argue that the integration of BCT, the DAE, and OAT is well-suited to reshape the landscape of advertising markets, given the comprehensive coverage, interconnectivity, and flexibility that this integration affords, and given our focus on relating and integrating the findings (MacInnis 2011). However, it is essential to remain aware of their potential limitations and adapt the integrative framework as needed to address any new or emerging trends.

Research Methodology

Step 1: Use Case Selection

Academics envision ABA use cases to achieve the emerging collective object of digital advertising with data-rich environments (Gupta et al. 2020), weaken related communities of digital advertising through disintermediation (Hooper and Holtbrügge 2020), or strengthen the customer–brand relationship with increasing ad targeting precision (Gleim and Stevens 2021). In this section, we consider specific ABA use cases, which we identified through a systematic literature review with predefined inclusion and exclusion criteria (Gensler et al. 2013; Verma and Yadav 2021). We began with a first round (R1) of systematic literature reviews on Clarivate Analytics' Web of Science in the first half of June 2021, in which we checked for the presence of publications that mentioned both "blockchain" and "advertising" in the full body of the text. This review identified 11 articles published in conference proceedings and 20 articles published in journals. In a second round (R2), undertaken in the second half of June 2021, we examined the content of these texts, excluding any whose focus was on cryptocurrencies. To keep our findings as relevant as possible, in May 2022, we repeated the R1 and R2 steps in a third round (R3) and added 11 publications to our list, 8 of which we excluded on the basis of the R2 criteria. Between December 2022 and January 2023, we repeated the R1–R3 steps (R4) and added 14 publications to our list, 4 of which we excluded on the basis of the R2 criteria. No additional use cases were added to our list during R3 or R4. As Figure 2 (Step 1) shows, our review resulted in three research types in accordance with knowledge transfer theory: knowledge creation (research agenda propositions [RAP]), knowledge diffusion (application guides [GUI]) and knowledge utilization (application investigations [INV]) (Gera 2012). We found no instances of knowledge adoption literature.

The analysis yielded 15 INV, 13 RAP, and 7 GUI. Next, we performed a thorough manual analysis of the content of these 35 publications in our search for ABA use cases, looking for anchoring text particles (Gordon et al. 2021; Stallone, Wetzels, and Klaas 2021) that reliably imply the presence and description of such use cases (Vasques et al. 2019). Table 2 lists the use cases, the sources mentioning the use cases and the specific ABA. We found 25 unique and specific examples of ABA mentioned in these publications, 10 of which had ceased to exist by the time we conducted R4 (Table 2; inactive ABA examples appear in italics). Appendix Table A1 lists the sources we identified and depicts the use cases mentioned per source.

The average number of use cases per publication is 2.51. The average number of mentioned use cases by research types is as follows: RAP = 3.86, GUI = 1.56, and INV = 1.62. Combining the adtech taxonomy of Gordon et al. (2021), the descriptions of the use case categorizations in Stallone, Wetzels, and Klaas (2021), the theoretical implications recommended by Joo et al. (2023), and the innovation taxonomy of Blackler, Crump, and McDonald's (2000) organizational system map, we propose the subdivision of these use cases into three innovation areas. In the following subsection, we examine the use cases we identified in the literature (UC 1–10 in Table 2) discussing the specific ABA within.

Boundary innovations. BCT has the potential to enhance advertising execution by optimizing the processes of buying and selling, facilitating the implementation of smart contracts, and automating the settlement of payments. Such features lead to increased efficiency and transparency within the DAE.

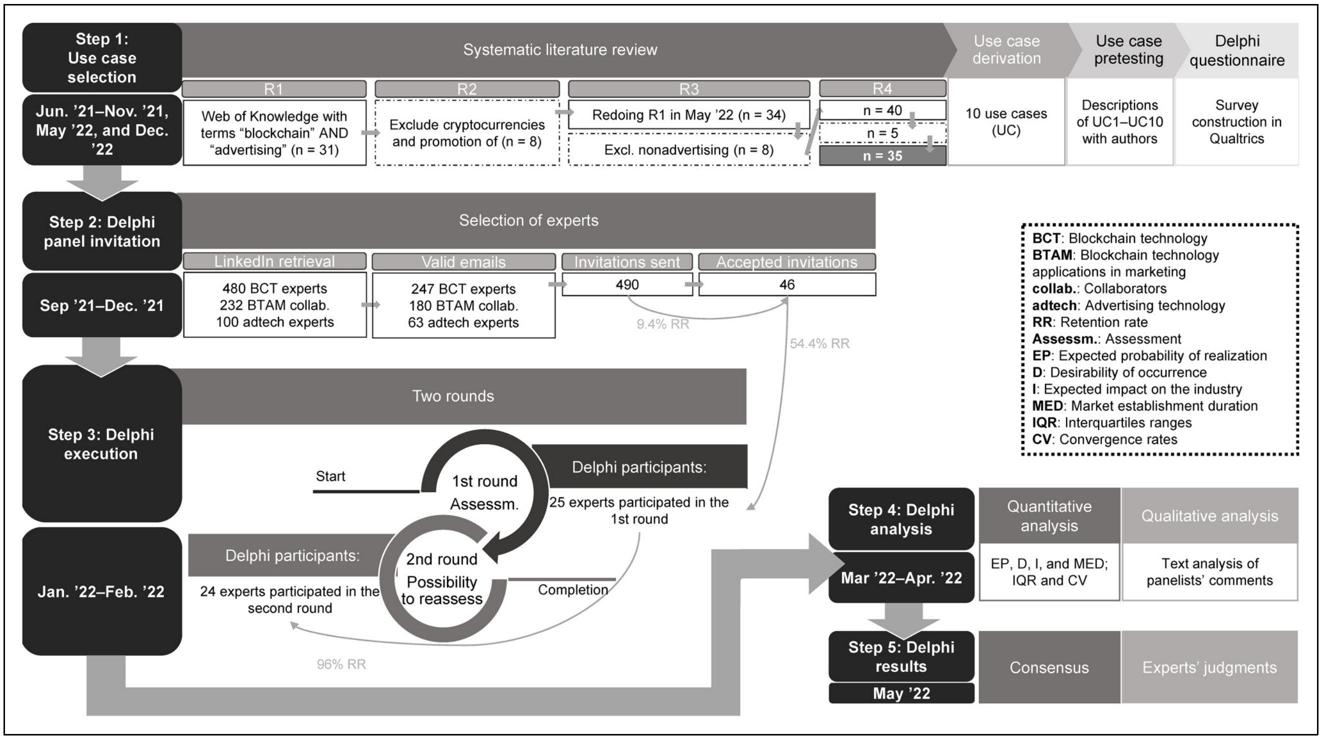

Figure 2. Methodology Applied Herein.
Notes: Design based on Kopyto et al. (2020).

Digital advertising supply chain transparency (UC1) describes the transparent data transitions that occur from the moment a user visits a publisher's website (or app) to when that user interacts with an advertiser's web presence by clicking on the ad (Tauro, Panniello, and Pellegrino 2021). A demand-side platform buys the right to place advertising on the publisher's inventory of websites. A supply-side platform coordinates and manages the distribution of inventory lists. A data management platform unifies the different sources of zero-, first-, second-, and third-party audience data used by advertisers to target users.

The applications in this field aim to increase trust among the DAE stakeholders (Swani, Milne, and Slepchuk 2021) by enhancing the availability of relevant information for rational decision making, in contrast with hidden agendas and conditions. Of the 16 publications containing this use case, 9 mention more than one company applying BCT. MetaX, the company behind AdChain (neither of which exists anymore), focused on supply chains in market settings in general (Anjum, Sporny, and Sill 2017; Boukis 2019; Chen et al. 2018; Liu, Zhang, and Han 2021; Mohindru et al. 2019; Pärssinen et al. 2018; Stallone, Wetzels, and Klaas 2021; Yun and Strycharz 2022). MadHive prioritizes over-the-top advertising transparency for (connected) television (Chen et al. 2018; Liu, Zhang, and Han 2021; Mohindru et al. 2019; Pärssinen et al. 2018). The NYIAX, launched by NASDAQ, handles exchanges of a premium advertising marketplace using a matching engine (Mohindru et al. 2019; Pärssinen et al. 2018; Peres et al. 2023; Stallone, Wetzels, and Klaas 2021). Similar to AdChain, AdEx facilitates the trading of advertising space and subsequent verification and proof that it has actually occurred (Liu, Zhang, and Han 2021; Pärssinen et al. 2018). Liu, Zhang, and Han (2021) mention three other platforms—two of which, Papyrus and POPC, no longer exist, and Kind Ads, which focuses on setting up new channels for advertisers and publishers to collaborate in the ecosystem in a transparent way. Tan and Saraniemi (2022) discuss two other platforms, which claim to improve the proposition of programmatic advertising by offering protocol layers (AdShares) and to implement an advertising transaction data exchange layer supporting industry standards such as Open RTB 2.5, the General Data Protection Regulation, and the California Consumer Privacy Act (Alkimi).

Three papers present their own applications in the field of ad supply chain transparency: Liu, Huang, et al. (2020) investigate privacy-preserving accountability in advertising networks and provide benchmarks for feasibility. Liu, Ni, et al. (2020) and Li et al. (2019) discuss a similar application, but focus on its adaptation to vehicular advertising. Colicev (2023) mentions the application of BCT in enhancing transparency of the DAE supply chain, taking the perspective of the promotion of nonfungible tokens (NFTs). Four publications mention this ABA use case; however, they do not mention specific ABA (Hooper and Holtbrügge 2020; Lax and Russo 2019; Li et al. 2019; Portnoff et al. 2017).

Ad fraud mitigation (UC2) and its interpretation, which is not directly observable in the data reported, has been subject to skepticism from both practitioners and scholars (Gordon et al. 2021). The contraposition of a false positive ("I see ad fraud

Table 2. Overview of Use Cases.

Innovation Clusters	Use Case Abbr.	Use Case Title	References and Amount		Specific ABA and Amount	
Boundary innovations	UC1	Ads supply chain transparency	Anjum, Sporny, and Sill (2017); Boukis (2019); Chen et al. (2018); Colicev (2023); Hooper and Holtbrügge (2020); Joo et al. (2023); Lax and Russo (2019); Li et al. (2019); Liu, Huang, et al. (2020); Liu, Ni, et al. (2020); Liu, Zhang, and Han (2021); Mohindru et al. (2019); Pärssinen et al. (2018); Peres et al. (2023); Portnoff et al. (2017); Stallone, Wetzels, and Klaas (2021); Tan and Saraniemi (2022); Yun and Strycharz (2022).	16	*MetaX*, *AdChain*, MadHive,a NYIAX,[b] AdEx,[c] *Papyrus*, *POPC*, Kind Ads,[d] Akimi,[e] and AdShares[f]	6, *4*
	UC2	Ad fraud mitigation	Boukis (2019); Chen et al. (2018); Ding et al. (2021); Gleim and Stevens (2021); Maestre (2019); Joo et al. (2023); Lyu et al. (2022); Marthews and Tucker (2023); Pärssinen et al. (2018); Peres et al. (2023); Stallone, Wetzels, and Klaas (2021); Xin and Zhang (2020); Yun and Strycharz (2022).	11	*MetaX*, Ubex,[g] Blockgraphh	2, *1*
	UC3	Content verification	Esmaili and Javidan (2020); Ding et al. (2021); Peres et al. (2023); Stallone, Wetzels, and Klaas (2021); Xin and Zhang (2020); Yun and Strycharz (2022).	5	*Civil*, *PUBLIQ*, and *ATMChain*	*3*
Contextual innovations	UC4	Rewarding content creators	Chang and Chen (2022); Esmaili and Javidan (2020); Liu, Zhang, and Han (2021); Peres et al. (2023); Stallone, Wetzels, and Klaas (2021); Xin and Zhang (2020).	5	*Civil*, *PUBLIQ*, and *ATMChain*	*3*
	UC5	User data security	Aujla et al. (2020); Bajoudah, Dong, and Missier (2020); Barati and Rana (2020); Boukis (2019); Chen et al. (2018); Hooper and Holtbrügge (2020); Jaime Maestre (2019); Joo et al. (2023); Lax and Russo (2019); Marthews and Tucker (2023); Mohindru et al. (2019); Pärssinen et al. (2018); Peres et al. (2023); Shi, Gao, and Guan (2022); Stallone, Wetzels, and Klaas (2021); Tan and Saraniemi (2022); Yun and Strycharz (2022).	15	Filecoin,[i] Databroker DAO,[j] Datapace,[k] *AnyLedger*, IOTA,[l] Streamr,[m] Blockstack,[n] Snov.io,[o] AdEx,[c] and Bravep	9, *1*
	UC6	Rewarding web users	Boukis (2019); Gleim and Stevens (2021); Hooper and Holtbrügge (2020); Joo et al. (2023); Mohindru et al. (2019); Pärssinen et al. (2018); Peres et al. (2023); Stallone, Wetzels, and Klaas (2021).	6	Ubexg and Bravep	2
Domain innovations	UC7	Mobile advertising	Chang and Chen (2022); Li et al. (2019); Liu, Ni, et al. (2020); Pärssinen et al. (2018); Pittaras et al. (2021); Purnama et al. (2021); Shi, Gao, and Guan (2022); Smith et al. (2022).	8	—	0
	UC8	Social advertising	Cha et al. (2018); Joo et al. (2023); Lax and Russo (2019); Peres et al. (2022); Tan and Saraniemi (2022); Xin and Zhang (2020).	6	—	0
	UC9	Affiliate advertising	Baldominos Gómez, López-Sánchez, and Acevedo-Aguilar (2020); Peres et al. (2022).	2	*Blockverse*	*1*
	UC10	Search engine advertising	Mohindru et al. (2019).	1	*BitClave*	*1*

Notes: Italic font = inactive ABA. The specific ABA mentioned can be found here: (a) https://www.madhive.com/; (b) https://www.nyiax.com/; (c) https://www.adexpartners.com/; (d) https://kindads.io/; (e) https://www.alkimi.org/; (f) https://adshares.net/; (g) https://ubex.com/; (h) https://www.blockgraph.co/; (i) https://filecoin.io/; (j) https://www.databroker.global/; (k) https://open-ecosystem.org; (l) https://www.iota.org/; (m) https://streamr.network/; (n) https://docs.stacks.co/; (o) https://snov.io/; (p) https://brave.com/.

where there is not") versus a false negative ("I should have seen ad fraud, but I did not") tends to intensify discussions about transparent mitigation management within the advertising ecosystem without having to add more intermediaries to the data flow (Yun et al. 2020). Ding et al. (2021) and Lyu et al. (2022) present their own blockchain-based digital advertising media system (B2DAM and BCFDPS, respectively) to mitigate fraudulent activities by publishers that try to improve click-through rates. Chen et al. (2018), Gleim and Stevens (2021), and Hooper and Holtbrügge (2020) mention MetaX, Ubex, and Blockgraph, respectively, in the context of their promises to counter fraud in digital advertising. Xin and Zhang (2020) show how content producers can protect themselves from fraudulent traffic and invalid delivery issues with an application guide for BCT. Boukis (2019), Maestre (2019), Marthews and Tucker (2023), Pärssinen et al. (2018), Peres et al. (2023), and Yun and Strycharz (2022) also discuss ad fraud mitigation but without mentioning specific ABA. Pärssinen et al. (2018) analyze the main blockchain platforms (including Bitcoin, Ethereum, Ripple BitShares, and Omni Layer) to determine which meet the requirements and address the challenges of ad fraud.

Disinformation refers to spreading information with the intent to deceive (Visentin, Pizzi, and Pichierri 2019). To counteract disinformation, publishers and social network sites have rigorous systems in place to verify authenticity of content (UC3) (Müller and Schulz 2019). Xin and Zhang (2020) show how BCT can verify content by rewarding content creators, thereby increasing the value of a publisher's website for potential advertisers. Civil, PUBLIQ, and ATMChain were platforms active in the field of media distribution and verification (Liu, Zhang, and Han 2021). It is worth noting that none of these mentioned ABA platforms is still active. In describing the challenges of content verification, Esmaili and Javidan (2020) investigate a BCT application to verify video content. Neither Peres et al. (2023) nor Yun and Strycharz (2022) name any specific ABA in their publication, though they mention both use cases.

Contextual innovations. BCT can bolster the security and privacy of user data, enabling advertisers to gain deeper comprehension of their target demographics and more effectively deliver advertisements. In addition, BCT can serve as a mechanism to incentivize users' online engagement and compensate content creators for their input, thus promoting a more user-focused environment within the DAE.

Content creators, who are not bound by contractual obligations, cocreate value for platform operators and may spread misinformation accidentally or deliberately. Some platforms include reward mechanisms to address potential motivational problems (UC4) (Huang et al. 2019). In this content-related application case, blocking advertising might put these types of media out of business by reducing ad revenue. Esmaili and Javidan (2020) investigate a BCT application that rewards downloaders (users) and uploaders (content creators) as part of its controlling and monitoring mechanisms. Neither Liu, Zhang, and Han (2021) nor Peres et al. (2023) name any specific ABA in their publication, though they mention both use cases. Xin and Zhang (2020) show how BCT can verify content by rewarding content creators, and Chang and Chen (2022) adopt this principle to podcasts.

User data security (UC5) is often presented in the context of data privacy and compliance (Aujla et al. 2020). The semantics may differ, but the terms serve a similar objective—namely, protecting sensitive data. To this end, requirements are set and followed. As a concept, user data security is somewhat in conflict with the main functional aspects of the DAE. To show relevant ads to users, advertisers must collect user data (Bashir and Wilson 2018). Gordon et al. (2021) highlight the need for more signals (or additional user data) to increase market transparency, in line with Pärssinen et al.'s (2018) proposed "quasi-transparency" notion. Of the 15 publications with this use case, 4 mention a specific application. Hooper and Holtbrügge (2020) refer to Algebraix, an implementation of BCT in pursuit of improved consumer privacy (now inactive). Filecoin, mentioned by Boukis (2019), offers an open-source cloud storage marketplace, protocol, and incentive layer, which, in our opinion, does not serve the DAE directly. Bajoudah, Dong, and Missier (2020) present a guide for a data marketplace architecture and mention different applications that focus on Internet of Things data trading (DataBroker DAO, Datapace, AnyLedger [out of business], IOTA, and Streamr). However, they do not explore in detail why these applications are important from a user data security perspective. Blockstack, mentioned by Mohindru et al. (2019, p. 88), allows users "to visit [web]sites with their data privacy [assured]." A visit to the website, however, shows that the company changed its name and focus, so it now offers authentication, transaction signing, and data storage guides for BCT developers rather than any specific ABA-related service. Mohindru et al. (2019) also mention Snov.io. However, this company is not an ABA; it pursued advertising to increase the valuation of its initial coin offering in 2017 (ICObench 2021). Pärssinen et al. (2018) describe how Brave and AdEx, by storing only critical user data, sought to increase and improve users' data privacy in the DAE. Apart from Shi, Gao, and Guan (2022) and Aujla et al. (2020), who present their own application guides for cross-app advertising and compliance-aware applications that might be adopted by advertising ecosystems, we find no other concrete applications for user data security purposes in publications discussing this topic (Barati and Rana 2020; Chen et al. 2018; Maestre 2019; Lax and Russo 2019; Marthews and Tucker 2023; Peres et al. 2023; Tan and Saraniemi 2022; Yun and Strycharz 2022).

According to Gordon et al. (2021), incentivizing web users can improve advertising allocation mechanisms. Rewarded ads (UC6) incentivize users to watch ads in exchange for a virtual good. The advertising ecosystem does not have any virtual goods to offer (Toksoz and Dukellis 2018). However, in these use cases, users can be compensated for their attention. For example, Ubex, an application that addresses advertising fraud in the ecosystem, seems to work as an incentive for users, enabling them "to opt-into viewing ads" and be “rewarded for interacting with them” (Gleim and Stevens 2021, p. 127). Apart from improving ad supply chain transparency, Algebraix helps with targeting and incentivizing “prospects on the network” by paying “the prospects that interact with the content … in tokens” (Hooper and Holtbrügge 2020, p. 191). Similarly, Brave allows digital ad exchanges between consumers and advertisers, where rewards are given for consumers’ attention when viewing ads (Boukis 2019). However, all these ABA examples remain vague in their explanation of how rewarding web users should actually work (Mohindru et al. 2019; Pärssinen et al. 2018; Peres et al. 2023).

Domain innovations. BCT can facilitate the emergence of novel advertising channels and platforms, capitalizing on the decentralized and open characteristics of the technology to establish alternative paradigms that contest prevailing monopolies and stimulate innovation.

The widespread use of mobile devices has led advertisers to target users while they are away from their homes or workplaces, such as when they browse the web or use an app on mobile devices (Kurtz, Wirtz, and Langer 2021). Mobile operating systems are more intrusive when it comes to data collection, which influences the ad experience users might have (Hayes et al. 2021). In turn, scholars investigate applications of BCT in mobile advertising (UC7). Shi, Gao, and Guan (2022) propose a smart contract–based personal data protection framework for in-app and cross-app tracking. Smith et al. (2022) present ScreenCoin, a Blockchain-enabled decentralized out-of-home ad screen network. Chang and Chen (2022) depict their solution for a mobile-based ad network that rewards podcast creators. Pittaras et al. (2021) present an application guide for a mobile gaming platform based on BCT and show how advertisers might benefit from placing contextual or behavior-based targeted ads and rewarding users for their attention. In their study of vehicular advertising, Li et al. (2019) consider how it might be achieved technically, in light of difficulties of vehicle-to-vehicle communication systems and the development of in-vehicle entertainment systems. Three publications mention this ABA use case; however, they do not disclose any specific ABA (Liu, Ni, et al. 2020; Pärssinen et al. 2018; Purnama et al. 2021).

Social media ads (UC8) represent the cutting edge of brand–consumer communications due to their interrelated, interactive, and communicative nature (Mahmood and Sismeiro 2017). Unfortunately, they are easy to sabotage with fraudulent profiles (Gordon et al. 2021; Peres et al. 2023). At the same time, these interactions come at a cost—namely, users’ privacy and data. Xin and Zhang (2020) explore news platforms and the effects that social advertising on Facebook and other social media have on the DAE profit model. They explain that social ads have overturned the process of secondary sales on news platforms. Their guidelines suggest implementing BCT to make news platforms more socially interactable and to avoid disseminating fake news. Cha et al. (2018) and Joo et al. (2023 propose guidelines for the development of a BCT application that integrates social advertising into peer-to-peer e-commerce systems. An application based on Ethereum enables a social network to comply with user preferences by turning it into a publicly available blockchain (Lax and Russo 2019). Two publications mention this ABA use case without disclosing any specific ABA (Peres et al. 2023; Tan and Saraniemi 2022).

Affiliate advertising (UC9) is usually a performance-based method of incentivizing third parties to advertise a company’s services or products by offering them a commission. An affiliate earns a commission if a user makes a purchase after interacting with a hyperlink presented by the affiliate (Abou Nabout et al. 2012). This ABA expands the previously mentioned supply chain in the advertising ecosystem beyond a click on the ad and toward a more goal-oriented interaction by the user, such as a transaction, a newsletter subscription, or entry into contract. Baldominos Gómez, López-Sánchez, and Acevedo-Aguilar (2020) find that complex schemes in affiliate advertising make the secure tracking and identification of users an essential requirement for affiliates to agree to commissions. It results in some distrust though, which is why Blockverse (discontinued in 2020) was proposed as a BCT-based platform to create deals between companies (merchants) and publishers (affiliates) and take care of the commission’s complex payment agreements (affiliate fees). Peres et al. (2023) do not mention affiliate advertising directly but describe its functionality when discussing how influencer advertising could benefit from the application of BCT.

Advertisers pay a fee to internet search engines for their ads to be displayed above, alongside, or underneath organic web search results (Bayer et al. 2020). Although the biggest search engines worldwide (Google, Bing, Baidu, Yandex, Yahoo, DuckDuckGo, Naver, and Ecosia; Net MarketShare 2021) use distributed architecture, they have centralized control over their search engine ads (UC10), which leads to privacy violations (unwanted storing of users’ search history) and monopoly (threatening information distortion) (Rezaee, Saghiri, and Forestiero 2021). Only one paper (Mohindru et al. 2019) mentions the application of BCT in search engine advertising with BitClave (ceased in 2020), again without giving any context.

Delphi Study

In the previous subsections, we identified potential use cases for further study. In the following subsections, we explore the appropriate method to undertake an investigation of these use cases to establish claims about their (potential) feasibility.

Delphi method. Using the Delphi method makes sense whenever there is a “lack of agreement or incomplete state of knowledge concerning either the nature of the problem or the components which must be included in a successful solution” (Delbecq, Van de Ven, and Gustafson 1975, p. 5). This methodology should facilitate the understanding and application of necessary knowledge to discern answers to the queries about solution fields posed in this article. (Gera 2012). In line with scholars facing similar research questions in the field of

Table 3. Experience and Project Tiers of Delphi Panel Participants in Both Rounds.

	BCT						Adtech					
	Experience (in Years)			Number of Projects			Experience (in Years)			Number of Projects		
	Tier Def.	Count	Averages	Tier Def.	Count	Averages	Tier Def.	Count	Averages	Tier Def.	Count	Averages
Tier 1	0–3	4	2.00	0–2	7	.86	0–3	9	.30	0–1	10	.3
Tier 2	4–5	8	4.25	3–6	10	3.60	4–7	8	5.25	2–3	5	2.2
Tier 3	6+	12	7.67	7+	7	17.43	8+	7	26.14	4+	9	41.44
Total		**24**	**5.58**		**24**	**6.83**		**24**	**9.50**		**24**	**16.13**

BCT or adtech (Jain, Sharma, and Shrivastava 2021; Kopyto et al. 2020; Kurtz, Wirtz, and Langer 2021), we developed an expert-based study, with the underlying assumption that industry experts with appropriate backgrounds (i.e., stakeholders of BCT, the DAE, or both) can evaluate predefined use cases.

Using differentiations noted by Linstone and Turoff (1975), we undertook a thorough Delphi-based use case analysis. Two main motives led to our final decision about how to proceed. First, our goal was consensus among a group of experts who could change their opinions without coercion, on the basis of controlled feedback from the research coordinator (Linstone and Turoff 1975). Second, two or three iterations are sufficient to arrive at a consensus for most studies. We therefore apply a classic two-round Delphi method (Skulmoski, Hartman, and Krahn 2007).

Step 2: Expert sampling and panel composition. Early in our research, we identified three sources of relevant experts. In research for the Frankfurt Business School, Sandner (2020) created a list of more than 480 BCT experts, including first and last names and LinkedIn profiles. Using this list, we retrieved valid email addresses for 247 BCT experts. In addition, Stallone, Wetzels, and Klaas (2021) list 800 BCT applications that feature the names of companies. In our search for BCT experts, we first identified the companies' Crunchbase and LinkedIn profiles to identify collaborators working for them, resulting in a list of 232 potential respondents, which we further narrowed down to 180 BCT experts with valid email addresses. Finally, we sought participants with extensive expertise in adtech. Using information available online, we compiled a list of 100 adtech experts via AdTech Weekly (2021) with first and last names and LinkedIn profiles. From this list, we retrieved valid email addresses for 63 adtech experts. Of the resulting 490 experts we invited to participate in our two-round Delphi study, 46 accepted.

Step 3: Delphi study approach. In the internet-based Delphi study, the experts received two surveys (generated with Qualtrics) to complete, one in early January 2022 and one in early February 2022. This approach increases our flexibility in designing the survey, but it compromises the real-time setup of the Delphi study. Participants accessed the surveys by clicking on links they received in an email. Of the 46 experts who agreed to participate in the two-round Delphi study, 25 (54.3%) completed the first round in January 2022, and, out of these 25 participants, 24 (96%) completed the second round in February 2022. This panel composition procedure helps establish one of the key value propositions of our study, which also offers international views (12 countries[1]).

Given the emerging and rapidly shifting nature of the topic, we acknowledged that not all participants would possess a uniform comprehension of every aspect of the use cases. To ensure uniform familiarity, we took three measures. First, as noted, we undertook careful expert sampling and composition. Second, we provided these experts with information and short descriptions of the use cases. As researchers with prior knowledge of the topic, we created outlines of the fundamental knowledge and presented all participants with identical information (Kezar and Maxey 2016). Third, as in Müller, Linders, and Pires's (2010) Delphi study, we disclosed the answers of the panelists in a first round report with overall averages, as well as peer-circle averages. We asked the experts to self-assess their expertise by answering questions about how long they had been working in their field (BCT or adtech) and the number of projects in which they had been involved. For each professional expertise input, we subdivided the experts into three tiers. Table 3 shows that, from the perspective of their experience in BCT, four experts should be put into Tier 1; their average experience in this field was two years (for a full disclosure of all experts, see Table A2 in the Appendix). At the time of the first round, our experts had an average 5.58 years of experience in BCT and 9.5 years of experience in adtech and had been involved in an average of 6.83 BCT projects and 16.13 adtech projects. Given the relative newness of both sectors (the first mention of BCT, according to the Web of Science, is Decker and Wattenhofer [2013], and the first mention of adtech is Colombo and Lambertini [2003]), we concluded that the average values correspond expertise expectancy.

In a quantitative assessment in line with Kopyto et al. (2020), we asked each expert to rate the use cases according to the following criteria:

[1] China, Cyprus, Finland, France, Germany, Italy, Latvia, Luxembourg, the Netherlands, South Africa, Switzerland, and the United States.

Table 4. Analysis of Experts' Ratings.

		EP			I			D			MED		
		Avg. (%)	IQR (%)	CV (%)	Avg.	IQR	CV (%)	Avg.	IQR	CV (%)	Avg.	IQR	CV (%)
UC1	Ads supply chain transparency	58.40	36	−3.45	3.32	*1*	−5.87	3.50	2	−15.09	6.44	*2*	−8.58
UC2	Ad fraud mitigation	54.04	31	−9.98	3.52	*1*	−9.89	3.96	*0*	−5.91	6.52	5	−18.73
UC3	Content verification	59.64	30	−19.54	3.76	*1*	−21.03	3.84	2	−14.34	6.76	*3*	−17.06
UC4	Rewarding content creators	74.16	31	−16.48	3.84	*1*	−8.33	3.92	*1*	−10.65	4.76	*2*	−6.10
UC5	User data security	63.44	32	−12.91	3.76	*1*	−15.80	3.96	2	−5.58	7.32	5	−33.37
UC6	Rewarding web users	77.92	30	−15.66	3.84	2	−6.11	3.76	*0*	−7.47	4.32	*3*	−11.71
UC7	Mobile advertising	52.72	42	−15.14	3.08	*1*	−9.46	2.88	2	−16.38	6.40	*4*	−13.87
UC8	Social advertising	59.72	39	−10.90	3.12	*1*	−7.62	3.16	*1*	2.40	5.40	*3*	−10.33
UC9	Affiliate advertising	53.44	41	−14.72	2.80	*1*	−7.47	2.72	*1*	−7.14	6.44	*4*	−14.79
UC10	Search engine advertising	40.52	30	−9.80	2.56	*1*	−10.27	2.72	*1*	−8.85	9.16	6	−6.64
Contextual innovation (UC4, UC5, and UC6)		71.84	30.00	−20.17	3.81	*1*	−3.85	3.88	*1*	−10.66	5.47	*2.33*	−19.45
Boundary innovation (UC1, UC2, and UC3)		57.36	*21.67*	−11.27	3.53	*1*	−11.41	3.79	*1*	.87	6.57	*1.67*	−9.85
Domain innovation (UC7, UC8, UC9, and UC10)		51.60	*17.50*	−9.49	2.89	*.75*	−7.65	2.87	*.75*	−11.05	6.85	*3.75*	−6.05
Total		59.4	34.2	−12.86	3.36	*1.1*	−10.19	3.44	*1.2*	−8.90	6.35	*3.70*	−14.12

Notes: Mean panel consensus appears in italics. EP = expected probability of realization; I = expected impact on the industry; D = desirability of occurrence; MED = market establishment duration; IQR = interquartile range (IQR = ≤25 for EP, 1.25 for I and D, and 4 for MED); CV = convergence (i.e., decrease in standard deviation).

- Expected probability of realization, based on a 0%–100% metric scale.
- Expected impact on the industry, based on a five-point Likert scale.
- Desirability of occurrence by the stakeholders, based on a five-point Likert scale.
- Market establishment duration, based on a 0–20 metric scale.

We encouraged participants to add qualitative insights to the quantitative value estimates.

As Schlecht, Schneider, and Buchwald (2021) propose, we ensured retention and validity with a transparent approach. Specifically, we explained the procedure and next steps to participants at various stages of the study. The survey contained detailed (text) descriptions of the use cases, which we derived from our literature review. Immediately after the first round, each participant received an individual report containing quantitative and qualitative feedback (see Figure A1 in the Appendix). We included descriptive statistics for global average and for peer average values, which reflect answers by experts' peers, defined according to the tier in which we categorized them (Table 3), as well as other experts' written justifications of the answers they gave. By doing so, we involved stakeholders in finding the areas of agreement and disagreement that surfaced through the surveys. By presenting a consolidation of the survey feedback in the form of a first-round report, participants gained a more comprehensive understanding of the current scenario and the various viewpoints within the sample, as well as in their peer circles.

Step 4: Delphi study analysis. We determined the mean values of the expected probability of realization, expected impact on the industry, desirability of occurrence, and market establishment duration to summarize the experts' long-term judgments (Culot et al. 2020; Kopyto et al. 2020; Schweizer et al. 2020). We calculated two additional measures for each use case so that we could derive consensus mechanisms. The convergence rate helps us quantify the experts' changes (Kopyto et al. 2020), measured as the difference in the standard deviation of the average probability expectations from the first round to the second round, indicating their confidence in their responses (closer to 0 means more confident). The interquartile range indicates the final consensus/dissent levels for each projection. For this study, we defined an interquartile range of 25% of the maximal value on the scale (Kopyto et al. 2020), resulting in ≤25 for expected probability of realization, 1.25 for expected impact on the industry and desirability of occurrence, and 5 for market establishment duration. The experts provided 315 written comments (12.6 per expert), with 92% of the experts providing at least one explanation of their assessments, indicating a high level of participation.

Results

Our findings represent Step 5 of the methodological procedure in Figure 2. Table 4 provides the mean values of the use cases' expected probability of realization, expected impact on the

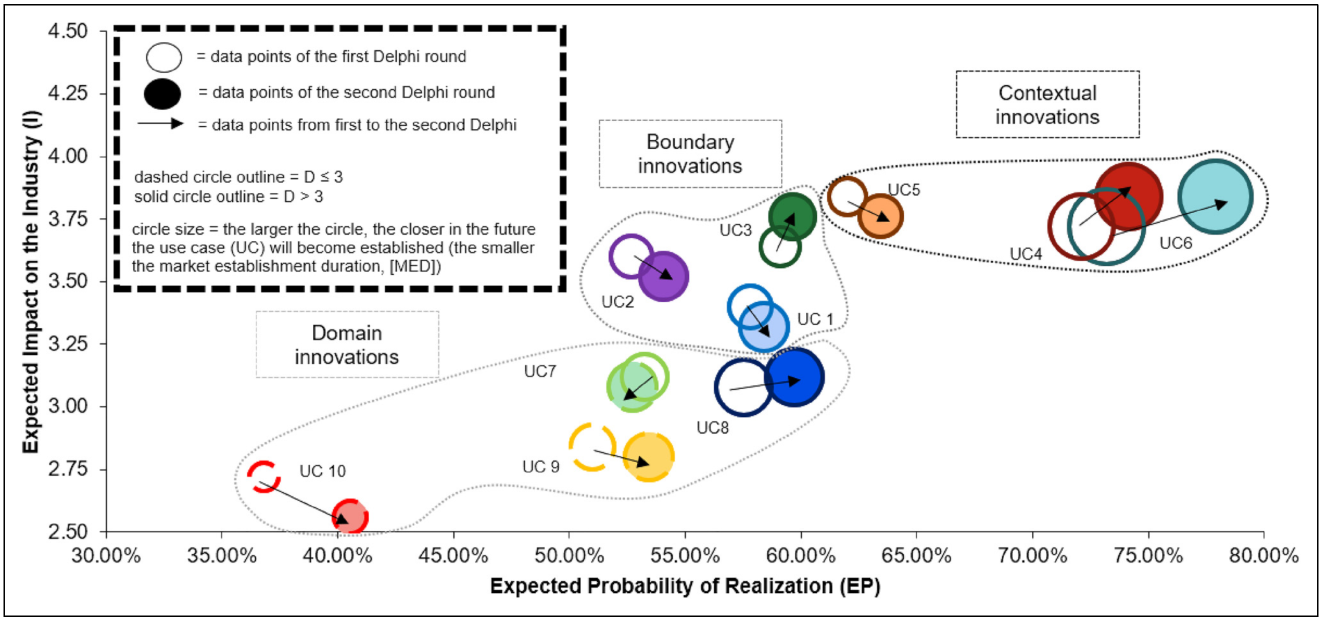

Figure 3. Classification of Use Cases Based on Expected Probability of Realization (EP), Expected Impact on the Industry (I), Desirability of Occurrence (D), and Market Establishment Duration (MED).

industry, desirability of occurrence, and market establishment duration, as well as interquartile range and convergence rate.

The use cases with the highest expected probability of realization are those with highest expected impact on the advertising industry, and the shortest market establishment duration (less than five years): rewarding web users (UC6; approximately 78%) and rewarding content creators (UC4; approximately 74%). The highest values for desirability of occurrence were achieved by two use cases aimed at improving rather than revolutionizing the current ecosystem: user data security and ad fraud mitigation, with mean values of 3.96.

The lowest expected probability of realization was attributed to search engine advertising (UC10; approximately 41%). Most use cases have a nonnegligible expected impact on the advertising industry (>3), except for affiliate advertising (UC9; 2.80) and search engine advertising (UC10; 2.56), which also present the lowest values for desirability of occurrence (2.72 and 2.72, respectively).

Analyses of the experts' answers with respect to the use cases' expected probability of realization, expected impact on the industry, desirability of occurrence, and market establishment duration provide the input for our main insights (Figure 3).

Use cases in the contextual innovation cluster have the highest average expected probability of realization (approximately 72%), expected impact on the industry (3.81), and desirability of occurrence (3.88) and the shortest market establishment duration (approximately 5.5 years) across the innovation fields (lower part of Table 4). Use cases in the domain innovation cluster have the lowest average expected probability of realization (51.6%), expected impact on the industry (2.89), and desirability of occurrence (2.87), and the longest market establishment duration (approximately 6.85 years). The two rounds of our Delphi study lead to a higher average expected probability of realization for all use cases (+3.22%), a lower expected impact on the industry (−.24%), a lower desirability of occurrence (−.52%), and a drastic reduction in market establishment duration (−7.78%).

Consensus

Calculating the interquartile range of the experts' expected probability of realization revealed that by applying the common threshold value of ≤25, not a single use case achieved consensus. Overall, standard deviations decreased for expected probability of realization by 12.86%, expected impact on the industry by 10.19%, desirability of occurrence by 8.9%, and market establishment duration by 14.12%, indicating overall convergence toward group consensus. Domain and boundary innovation–related use cases as a cluster achieved consensus for its mean value of expected probability of realization according to the interquartile range thresholds of 17.5% and 24.5% (≤25), respectively. On average, all innovation clusters achieved consensus (≤25) on all thresholds except for the expected probability of realization of contextual innovations (30%). Six use cases almost reached this threshold (UC2, UC3, UC4, UC5, UC6, and UC10), and five achieved consensuses on all variables (cf. expected probability of realization), according to the interquartile range threshold of ≤25 (UC3, UC4, UC7, UC8, and UC9).

A closer look at the convergence rates of our use cases leads us to note that digital advertising supply chain transparency (UC1) belongs to the use cases for which our panelists felt most confident in their assessment: the weakest convergences for the expected probability of realization (−3.45%) and the impact on the advertising industry (−5.87%), as well as one of the weakest convergences for the market establishment duration (−8.58%; third weakest behind UC10 and UC4). Digital advertising supply chain transparency (UC1) has the second strongest convergence for desirability, indicating low confidence in the assessment of whether this use case might please DAE stakeholders. Content verification (UC3) revealed the strongest convergence and lowest confidence among our panelists in their assessment of the expected probability of realization (−19.54%) and the impact on the industry (−21.03%), and one of the strongest convergences and therefore one of the lowest confidences for the assessment of the desirability (−14.34%) and market establishment duration (−17.06%).

Experts' Judgment

We can glean further insights into these with a deep dive into the experts' qualitative judgments of the use cases. We group these results by organizational activity induced innovation areas.

Boundary innovations. From a technological point of view, the use case of digital advertising supply chain transparency (UC1) might help rebuild trust in the adtech ecosystem. According to a few experts, because the ecosystem contains a lot of transactions (impressions), the application of BCT is well suited. However, two panelists had different opinions, claiming both that there is a need and that there is no need for trustless transactions in digital advertising supply chain transparency. The market is opaque, fragmented, and inefficient, so from an environmental perspective, BCT might be welcomed by stakeholders, though there would be difficulty aggregating needs-based solutions due to diversity within the ecosystem. This use case would create new dynamics, but it would be highly dependent on industrial adoption rates; because advertisers are paying for the whole ecosystem, they would be the primary stakeholder in furthering this adoption. Adoption also might be hindered by siloed thinking, hidden costs, hidden agendas, and transformative shifts in advertisers' expectations about the channel-related performance of digital advertising toward a more holistic view of brand performance. Organizations and stakeholders would face no apparent increase in trust in publishers, but overall trust in the system might increase ad spending and therefore serve as an incentive for the supply side.

From a technological perspective, as ad fraud increases, BCT might not be compatible and might be too slow for the number of transactions (impressions) in the first place and therefore not scalable. If ad fraud mitigation (UC2) works, it could reduce the number of intermediaries and increase the need for trust in a single point of truth, which intersects with one of BCT's unique propositions.

The applications of content verification (UC3) might be essential for democracies, but they may also limit freedom of speech. It is not entirely clear how ads might benefit from verified content, but it might increase trust in publishers. The first kind of content to be tackled should be user-generated content; however, it is not clear if BCT has any advantage over other technologies in this area.

Contextual innovations. A potential benefit of rewarding content creators (UC4) might be an increase in accountability in content creation, though BCT might not hold any singular advantage over other technologies. Smart contracts might not be able to identify whether content has been repeated. Such a solution is proposed solely by content creators, with no pressure from advertisers and publishers. The level of incentivization and reasoning behind the current situation led some experts to claim that so few content creators exist because there are few rewards, while other experts claim that there are so few rewards because there are so few content creators.

Adtech providers adopting BCT for user data security (UC5) would create an impressive relative advantage, because zero-knowledge advertising[2] is on the rise. The experts did not offer a clear consensus about whether achieving the application of this use case would depend on the willingness of policy makers, Big Tech, or relevant advertisers. The application of BCT in this field might also encounter legal barriers due to General Data Protection Regulation compliance and the need to establish data contracts with users. This use case could lead to data farms, which would sabotage the whole system. To apply such a use case consistently, accuracy is critical. Experts expect that an increase in users' data security at the individual level will lead to an increase in incentives and opportunities to monetize data flows and sets. The industry might want to encourage the development of universal solutions rather than walled gardens.

In combination with the verification of transactions (impressions) and verification of being human or not, BCT could reduce the technological complexity of rewarding web users (UC6). The advantage of using BCT over other technologies is not clear, but rewarded (e.g., play-to-earn) ads prompt better results. However, whether this use might lead to an overcommercialization of attention at the individual level is unclear.

Domain innovations. Success factors related to mobile advertising (UC7) might include industry standards and pressure set by the Internet of Things and augmented reality manufacturers. One benefit of this use case may be a reduction in the perceived intrusiveness of mobile devices, though putting geo-data on-chain could lead to problems. The electrical infrastructure needed for all the data points generated on mobile devices might be insufficient, which could hinder the scalability of such use cases.

From a technological perspective, applications of BCT within social advertising (UC8) only arise when they are highly intertwined with user identity (UC5) and asset ownership (UC3) applications. Companies in this field act as quasi-monopolies. These companies will lead the way if BCT holds any promise of advantage relative to other technologies. Business use cases include managing influencer marketing and future metaverse developments.

Affiliate advertising (UC9) is highly intertwined with the case of digital advertising supply chain transparency (UC1). UC9 could benefit from the application of smart contracts tracking web users beyond the click. The application of BCT in this field might revamp the whole field and the development of new platforms, though it would not change the business model of the affiliate industry.

[2] See Callejo and Cuevas (2021) for definitions of zero-knowledge advertising.

Technology companies in the field of search engine advertising (UC10) are too big, and there would likely be no change at all because search engine advertising is not a particular point of worry or concern in digital advertising.

Discussion

In our aim to understand and explicate the potential benefits of BCT, we integrate the applications of BCT in the DAE through the lens of OAT. By synthesizing knowledge in academic literature and that of managerial experts, we constructed an integrative, comprehensive, and flexible framework to classify BCT innovations in the interconnected DAE. In the following discussion, we develop an informed research agenda (see Table 5), which considers our findings, amalgamates them, and enriches them into an actionable set of research questions for academia and practice.

A key link is the focus on improving transparency and reducing fraud in the advertising industry. This theme is common in the boundary innovation cluster, which includes digital advertising supply chain transparency (UC1), ad fraud mitigation (UC2), and content verification (UC3). These use cases all aim to address issues of trust and transparency in the advertising ecosystem that have long been a concern for advertisers and marketers. By using BCT to create more transparent and auditable processes, these use cases could help reduce the risk of ad fraud and improve the overall effectiveness of ad campaigns. Boundary innovations, while the most frequently cited in RAP, INV, and GUI (see Table 2), do not have the highest scores for expected probability of realization, expected impact, or desirability. Combined with the high consensus in our two-round Delphi study on these values, we identify a tendency to idolize the potentialities in this area of innovation. In the judgments of the experts, we see a reflection of the conclusions of Joo et al. (2023), who almost exclusively focus on how BCT can overcome issues in advertising execution. The authors ask for (1) the aggregation of interests of the actors of the DAE, (2) openness for every advertiser and consumer but not for every publisher, (3) observability of transaction metadata, and (4) eligibility of the publisher's business model. We propose several research questions for this area of innovation. That is, when it comes to ABA,

1. What are the specific barriers to the aggregation of interests in different industries or market segments within the DAE, and how do regional or national regulations of digital advertising influence these barriers?
2. Which types of barriers (e.g., technological, regulatory, market-related) have the most significant impact on the adoption and implementation of ABA, and how can BCT applications address these barriers in different settings (e.g., large-scale advertising campaigns, niche marketing efforts)?
3. What role do interdisciplinary perspectives, cross-industry comparisons, and organizational diversity play in shaping the barriers to aggregating interests among actors in the DAE?

These questions touch on the literature on multi-actor systems, which highlights the importance of transparency and accountability in building trust between actors and facilitating cooperation (Huynh, Jennings, and Shadbolt 2006; Lewicki, Tomlinson, and Gillespie 2006), and on the adoption and implementation of ABA (Rogers, Singhal, and Quinlan 2014). The questions aim to address the challenges, obstacles, power dynamics and relative bargaining positions that arise when trying to align the interests of advertisers, publishers, and users. Prior literature in this area has explored various factors that influence the adoption and implementation of blockchain-based systems, such as perceived usefulness, perceived ease of use, attitude toward use, social influence, and innovation (Ardon et al. 2022; Cui et al. 2021; Gleim and Stevens 2021; Toksoz and Dukellis 2018; Treiblmaier et al. 2021). In the context of ABA, understanding the barriers to aggregation of interests is crucial for developing effective policies and strategies for the implementation of blockchain-based systems. Looking at factors such as the availability and distribution of resources; the costs of coordinating, cooperating, and executing among the actors in the DAE; and factors influencing the adoption and implementation of ABA (e.g., relative advantage, compatibility, complexity, trialability, observability) may help reveal specific challenges and obstacles to overcome to align the interests of the various actors and facilitate collaboration in the DAE.

Another connection between the use cases is the focus on empowering various stakeholders in the advertising industry. For example, rewarding content creators (UC4) aims to provide a more fair and transparent way for content creators to be compensated for their work, while rewarding web users (UC6) aims to provide a more fair and transparent compensation for web users and their attention. Similarly, user data security (UC5) aims to give users more control over their personal data and how it is exploited by advertisers. These use cases highlight the potential for BCT to disrupt traditional power dynamics in the advertising industry and provide more equitable outcomes for all stakeholders. For this area of innovation, when it comes to ABA,

1. How do the diverse preferences and expectations of rewards among different user groups (e.g., users with varying levels of privacy concerns, content creators in different industries) affect the design and effectiveness of BCT-based systems?
2. How can we develop optimal BCT-based systems that effectively reward content creators, web users, and data owners by considering diverse industry requirements, prioritizing user experiences, and adapting to evolving market innovations?

These questions relate to the body of knowledge on reward systems and user behavior in digital contexts, touching on the concept of perceived fairness in reward distribution and how it can influence user behavior and attitudes toward a system (Kelley 1978). Social exchange theory, which proposes that individuals engage in exchange relationships based on the perceived fairness of the exchange (Pérez-Sánchez et al. 2021),

Table 5. Research Questions, Recommended Research Methodologies, Research Contexts, Challenges and Data Availability.

Research Question	Recommended Research Methodologies	Research Contexts	Challenges	Data Availability
1. What are the specific barriers to the aggregation of interests in different industries or market segments within the DAE, and how do regional or national regulations of digital advertising influence these barriers?	Surveys or interviews with industry experts and stakeholders to gather their perspectives on the barriers to aggregation of interests.	Adtech companies, niche markets (e.g., e-commerce, travel, automotive), cross-national comparisons	Access to industry experts and stakeholders, biased responses, identifying and recruiting a representative sample	Low
	Case study analysis of existing ABA to identify common barriers and challenges	Comparing successful and unsuccessful ABA implementations, industry-specific case studies (finance, retail, health care), cross-platform case studies (e.g., display, search, social media)	Access to relevant case studies, comparability of case studies, subjectivity in case study analysis.	Medium
2. Which types of barriers (e.g., technological, regulatory, market-related) have the most significant impact on the adoption and implementation of ABA, and how can BCT applications address these barriers in different settings (e.g., large-scale advertising campaigns, niche marketing efforts)?	Experimentation using a ABA prototype system to test different solutions for overcoming barriers	Controlled lab environments, real-world pilot implementation, cross-industry comparisons	Developing a representative ABA prototype, time and resource constraints, ethical considerations	Low
	Action research with a select group of industry stakeholders to collaboratively identify and implement solutions for overcoming barriers	Industry collaborations, cross-functional teams, longitudinal studies	Stakeholder engagement, balancing research and practice, evaluating success	Low
3. What role do interdisciplinary perspectives, cross-industry comparisons, and organizational diversity play in shaping the barriers to aggregating interests among actors in the DAE?	Literature review to identify existing theories and explanations for barriers to aggregation of interests in DAE	Interdisciplinary perspectives, cross-industry comparisons, historical analyses	Scope and relevance, synthesis and integration, addressing gaps and limitations	High to very high
	Case study analysis of existing ABA to identify root causes of barriers	Industry-specific case studies, cross-national comparisons, organizational diversity	Selection bias, generalizability, data accuracy	Medium
4. How do the diverse preferences and expectations of rewards among different user groups (e.g., users with varying levels of privacy concerns, content creators in different industries) affect the design and effectiveness of BCT-based systems?	Surveys with content creators, web users, and data owners to gather their expectations and preferences for rewards in ABA	Demographic diversity, platform variety, user behavior	Response bias, sample representativeness, survey design	High
	User testing with prototypes of ABA to gather feedback on rewards and incentives	Reward mechanisms, user experience, platform integration	Prototype development, participant recruitment, user feedback interpretation	High
5. How can we develop optimal BCT-based systems that effectively reward content creators, web users, and data owners by considering diverse industry requirements, prioritizing user experiences, and adapting to evolving market innovations?	Design thinking workshops with a diverse group of stakeholders (e.g., content creators, web users, data owners, advertisers, publishers) to gather input on system design	Cross-industry collaboration, user-centered design, market trends and innovations	Stakeholder engagement, idea prioritization, iterative design	High
	Experimentation using a ABA prototype system to test different design solutions	Real-world testing environments, controlled laboratory environments, comparative analysis	Technical complexities, ensuring user engagement, data privacy and security	Medium
6. How do intermediaries active in the field of domain innovations impact the	Surveys or interviews with DAE actors in the field of mobile and social advertising to	Industry conferences and events, online industry	Access to relevant respondents, bias in responses,	Low

(continued)

Table 5. (continued)

Research Question	Recommended Research Methodologies	Research Contexts	Challenges	Data Availability
scalability and perceived intrusiveness of BCT-based systems?	gather their perspectives on scalability and perceived intrusiveness of ABA	forums and communities, in-depth case studies	representativeness of sample	
	Case study analysis of existing ABA for mobile and social advertising to identify common challenges and opportunities related to intermediaries	Cross-industry analysis, geographic comparison, longitudinal analysis	Access to case study data, comparability of cases, identifying causal relationships	Low
7. How do quasi-monopolies in the industry impact the potential advantages of BCT compared with other technologies?	Literature review of existing research on quasi-monopolies and their impact on innovation and technology adoption	Cross-sector analysis, temporal analysis, comparative analysis	Scope of the literature, conflicting findings, limited research on BCT	Very high
	Surveys or interviews with industry experts and stakeholders to gather their perspectives on the potential advantages and limitations of BCT compared with other technologies in the context of quasi-monopolies in the advertising industry	Geographical analysis, role-based analysis, market maturity analysis	Access to stakeholders, bias in responses, interpretation and generalizability	Very high

might lead to a better understanding of what rewards content creators, web users, and data owners expect in BCT-based systems and can therefore inform the design and implementation of these systems to ensure they are perceived as socially fair. The questions also relate to the concept of user-centered design, which emphasizes the importance of understanding and addressing the needs and desires of users when designing a system. Overall, designing these ABA to empower advertisers and users requires a holistic and user-centered approach that takes into account the needs and desires of all the stakeholders.

Several use cases focus on specific advertising channels or platforms. For example, mobile advertising (UC7) and social advertising (UC8) both aim to address specific challenges and opportunities related to these platforms. Similarly, affiliate advertising (UC9) and search engine advertising (UC10) focus on how BCT can be used to improve these specific types of advertising. We propose questions for this area of innovation, such that when it comes to ABA,

1. How do intermediaries active in this field of innovation impact the scalability and perceived intrusiveness of ABA?
2. How do quasi-monopolies in the industry impact the potential advantages of BCT compared with other technologies?

These questions relate to domain innovations within our integrative framework, specifically focusing on the role of intermediaries and the impact of monopolies in shaping the DAE. Domain innovations (distribution) pertain to the way activities and outcomes are allocated and diffused within the community, often influenced by intermediaries and dominant market players. Both questions relate to the concept of intermediation theory, which suggests that intermediaries, such as platforms or technology companies, play a pivotal role in facilitating transactions between producers and consumers in digital markets (Tapscott 2021). These intermediaries, in the context of domain innovations, can control market access and shape user perceptions of technology by determining the features and functionality of ABA. Furthermore, the questions draw on literature related to platform power, network effects (Subramanian 2017), and the impact of quasi-monopolies (Libai et al. 2020) in the DAE. Platforms with extensive user bases, such as mobile device manufacturers and mobile operating system providers, may exert considerable influence over the development and deployment of BCT-based systems for mobile advertising. This power could enable them to shape industry standards and user perceptions, potentially impeding the scalability of ABA. The presence of quasi-monopolies in the DAE may affect the potential advantages of BCT in various ways, such as dominant firms resisting the adoption of new technologies like BCT due to their established systems and processes. These firms may also have the resources and influence to direct industry standards and regulations in ways that favor their current systems and disadvantage emerging technologies like BCT. Research in this area could explore how policy makers can address the adverse effects of quasi-monopolies on competition and innovation in the digital advertising industry, ultimately contributing to a more balanced distribution of power and influence within the DAE and fostering domain innovations.

According to experts, researchers should start with questions 4 and 5 to make informed recommendations to practitioners about immediately necessary inputs. In addressing research questions 4 and 5, which focus on the rewards and system design expectations of content creators, web users, and data owners in BCT-based systems, it is crucial for researchers to consider diverse industry requirements, cultural contexts, and rapid technological advancements. These factors must be accounted for across various research methodologies, including surveys, user testing with prototypes, design thinking workshops, and experimentation with ABA prototype systems. Researchers should adopt multifaceted approaches to the challenges posed by diverse industry requirements, cultural contexts, and rapid technological advancements when exploring the rewards and system design expectations of content creators, web users, and data owners in BCT-based systems. By segmenting participants by industry, ensuring cultural sensitivity, and embracing an iterative and adaptive mindset, researchers can develop a deeper understanding of the factors influencing the design and implementation of effective and user-centric BCT-based reward systems in the DAE.

Next, we suggest moving on to questions 1, 2, and 3: these research designs require a deeper connection to stakeholders and therefore longer preparation times. In addressing research questions 1, 2, and 3, which focus on the barriers to the aggregation of interests of DAE actors, overcoming these barriers, and understanding the underlying reasons for these barriers, researchers must consider diverse stakeholder perspectives, real-world complexities, and the dynamic nature of the DAE. The suggested research methodologies for these questions include surveys, interviews, case study analysis, experimentation with ABA prototype systems, and action research. In summary, researchers should employ a comprehensive and adaptive approach to understand and address the barriers to the aggregation of interests of DAE actors. By considering diverse stakeholder perspectives, real-world complexities, and the dynamic nature of the DAE across various research methodologies, researchers can develop a robust understanding of the challenges, opportunities, and underlying reasons for the barriers in DAE. This understanding will pave the way for innovative solutions that foster cooperation, trust, and efficiency in the digital advertising industry.

For research questions 6 and 7, which focus on the impact of intermediaries and quasi-monopolies on the scalability, perceived intrusiveness, and potential advantages of BCT-based systems, researchers should be aware that while these questions may yield valuable insights, the Delphi study suggests that their findings might not have a direct, immediate impact on the industry. However, such research can still contribute to the broader understanding of the DAE and help inform future policy and strategic decisions. In summary, future researchers should adopt a comprehensive and long-term perspective when addressing research questions 6 and 7. By considering the diversity of intermediaries, the influence of quasi-monopolies, and the evolving nature of the DAE, researchers can contribute valuable insights to the field, informing strategic and policy decisions that may shape the industry's future development.

These research questions highlight the potential for BCT to transform the advertising industry, as well as the need for further research to understand the implications of this technology for various stakeholders.

Conclusion

Although the number of BCT applications in marketing, and specifically ABA, are increasing (Stallone, Wetzels, and Klaas 2021), the technology has been changing and manifesting different generational developments in application areas, in consensus models, in the utility of smart contracts, in energy and cost requirements, and in execution speed and scalability (Mukherjee and Pradhan 2021). Academia must consider these dynamics to stay relevant with respect to research methodologies and results in the field of BCT.

The current article contributes to bodies of knowledge in adtech, BCT, and OAT. Our literature review identifies 34 publications that touch on important ABA issues by proposing an integrative, comprehensible, and flexible framework and investigating applications and research questions. These publications yield ten ABA use cases: digital advertising transparency, user data security, rewarding web users, ad fraud mitigation, rewarding content creators, content verification, mobile advertising, social advertising, affiliate advertising, and search engine advertising. Our research represents the first empirical identification of ABA. We bounce them off our framework synthesizing ABA into three areas of innovation: domain, boundary, and context. To gather in-depth, long-term insights from these use cases, we applied a two-round Delphi methodology. The results delineate the expected probability of realization, expected impact on the advertising industry, desirability within the industry, and expected market establishment duration, with clear differences among the three innovation areas: Our research leads us to believe that use cases in the field of contextual innovations (rewarding content creators, user data security, and rewarding web users) will have the greatest impact on the industry and the highest expected probability of realization, though our panelists were least confident about the innovation area when assessing the expected probability of realization and market establishment duration. Thus, we propose research questions, including methodologies, to increase confidence in the use cases.

The limitations of this study provide opportunities for further research. We followed established practices to select our group of experts, but the results might be influenced by their biases (e.g., projection, belief, availability, confirmation, anthropic bias) (Valerdi 2011). Our research focuses on conceptual aspects of the development of the DAE and only touches on other aspects, such as regulation. Although providing a useful framework for understanding not only the DAE, but the ABA within, our results may oversimplify the complex nature of the system. We therefore expect scholars to challenge our findings and continue our integration processes with new, emerging innovations in ABA into the areas we have identified and discussed.

As Scott Galloway (2022) notes, "Scarcity and authenticity are powerful, and not always forces for good.… Amidst the scams and bubbles, credible scarcity and authenticity will unlock real value in digital markets."

Appendix

Table A1. BCT Publications on Advertising Retrieved via Systematic Literature Review.

No.	Author(s) (Year)	Type According to Gera (2012)	Use Cases	Use Cases Mentioned
1	Peres et al. (2023)	RAP	Rewarding web users, ad fraud mitigation, ad supply chain transparency, user data security, rewarding content creators, content verification, social advertising, affiliate advertising	8
2	Joo et al. (2023)	GUI	Rewarding web users, ad fraud mitigation, ad supply chain transparency, user data security, social advertising	5
3	Colicev (2023)	GUI	Ad supply chain transparency	1
4	Marthews and Tucker (2023)	RAP	Ad fraud mitigation, user data security	2
5	Smith et al. (2022)	INV	Mobile advertising	2
6	Yun and Strycharz (2022)	RAP	Ad supply chain transparency, user data security, ad fraud mitigation, content verification	4
7	Tan and Saraniemi (2022)	GUI	Ad supply chain transparency, user data security, social advertising	3
8	Chang and Chen (2022)	INV	Mobile advertising, rewarding content creators	2
9	Lyu et al. (2022)	INV	Ad fraud mitigation	1
10	Shi, Gao, and Guan (2022)	INV	Mobile advertising, user data security	2
11	Stallone, Wetzels, and Klaas (2021)	RAP	Ad fraud mitigation, ad supply chain transparency, rewarding web users, user data security, rewarding content creators, content verification	6
12	Liu, Zhang, and Han (2021)	RAP	Content verification, rewarding content creators, ad supply chain transparency	3
13	Gleim and Stevens (2021)	RAP	Ad fraud mitigation, rewarding web users	2
14	Ding et al. (2021)	INV	Ad fraud mitigation	1
15	Pittaras et al. (2021)	GUI	Mobile advertising	1
16	Purnama et al. (2021)	INV	Mobile advertising	1
17	Xin and Zhang (2020)	GUI	Ad fraud mitigation, social advertising, rewarding content creators, content verification	4
18	Liu, Huang, et al. (2020)	INV	Ad supply chain transparency	1
19	Liu, Ni, et al. (2020)	INV	Ad supply chain transparency, mobile advertising	2
20	Esmaili and Javidan (2020)	INV	Rewarding content creators, content verification	2
21	Aujla et al. (2020)	INV	User data security	1
22	Hooper and Holtbrügge (2020)	RAP	Ad supply chain transparency, user data security, rewarding web users	4
23	Baldominos Gómez, López-Sánchez, and Acevedo-Aguilar (2020)	GUI	Affiliate advertising	1
24	Barati and Rana (2020)	INV	User data security	1
25	Bajoudah, Dong, and Missier (2020)	INV	User data security	1
26	Boukis (2019)	RAP	Ad supply chain transparency, user data security, ad fraud mitigation, rewarding web users	4
27	Maestre (2019)	RAP	User data security, ad fraud mitigation	2
28	Lax and Russo (2019)	INV	Ad supply chain transparency, user data security, social advertising	3
29	Li et al. (2019)	INV	Ad supply chain transparency, mobile advertising	2
30	Mohindru et al. (2019)	RAP	Ad supply chain transparency, user data security, rewarding web users, search engine advertising	5
31	Pärssinen et al. (2018)	RAP	Ad supply chain transparency, user data security, ad fraud mitigation, rewarding web users	4

(continued)

Table A1. (continued)

No.	Author(s) (Year)	Type According to Gera (2012)	Use Cases	Use Cases Mentioned
32	Cha et al. (2018)	GUI	Social advertising	1
33	Chen et al. (2018)	RAP	Ad supply chain transparency, user data security, ad fraud mitigation	4
34	Anjum, Sporny, and Sill (2017)	RAP	Ad supply chain transparency	1
35	Portnoff et al. (2017)	INV	Ad supply chain transparency	1

Table A2. Delphi Panel Participants.

				Experience (in Years)		Project Amount	
No.	Full Name	Profession	Country	BCT (Tier)	Adtech (Tier)	BCT (Tier)	Adtech (Tier)
1	J.H.	Consultant	—[a]	4 (2)	0 (1)	50 (3)	0 (1)
2	R.T.	Entrepreneur and lecturer	Luxembourg	5 (2)	1 (1)	3 (2)	1 (1)
3	—	Postdoctoral researcher	Switzerland	6 (3)	0 (1)	4 (2)	0 (1)
4	M.K.	—	—	12 (3)	27 (3)	3 (2)	100 (3)
5	—	—	Switzerland	4 (2)	0 (1)	5 (2)	0 (1)
6	—	—	United States of America	2 (1)	7 (2)	3 (2)	20 (3)
7	C.G.	Entrepreneur	United States of America	14 (3)	35 (3)	5 (2)	100 (3)
8	—	CEO of a blockchain company	Germany	4 (2)	2 (1)	3 (2)	2 (2)
9	—	—	—	3 (1)	5 (2)	0 (1)	2 (2)
10	M.M.L.	Founder and CEO	—	6 (3)	16 (3)	15 (3)	2 (2)
11	A.H.	Business developer	Germany	5 (3)	30 (3)	7 (3)	30 (3)
12	—	—	—	7 (3)	4 (2)	10 (3)	10 (3)
13	—	—	—	7 (3)	0 (1)	20 (3)	0 (1)
14	P.Z.	—	—	4 (2)	27 (3)	1 (1)	15 (3)
15	E.C.	Cofounder and CMO	United States of America	4 (2)	7 (2)	2 (2)	24 (3)
16	L.R.	Associate professor	Italy	8 (3)	5 (2)	2 (2)	1 (1)
17	W.S.	Entrepreneur	Luxembourg	5 (3)	0 (1)	3 (2)	0 (1)
18	M.S.	Digital marketing consultant	Switzerland	0 (1)	5 (2)	0 (1)	24 (3)
19	K.F.	Lawyer	Germany	3 (1)	0 (1)	3 (2)	0 (1)
20	A.H.	Digital marketing strategist	—	9 (3)	25 (3)	0 (1)	3 (2)
21	—	Blockchain architect	China	7 (3)	0 (1)	10 (3)	0 (1)
22	—	Adtech CEO	South Africa	4 (2)	4 (2)	1 (1)	1 (1)
23	—	Entrepreneur	The Netherlands	5 (2)	5 (2)	4 (2)	2 (2)
24	J.L.	—	—	6 (3)	23 (3)	10 (3)	50 (3)

[a]— indicates that this information was not disclosed.

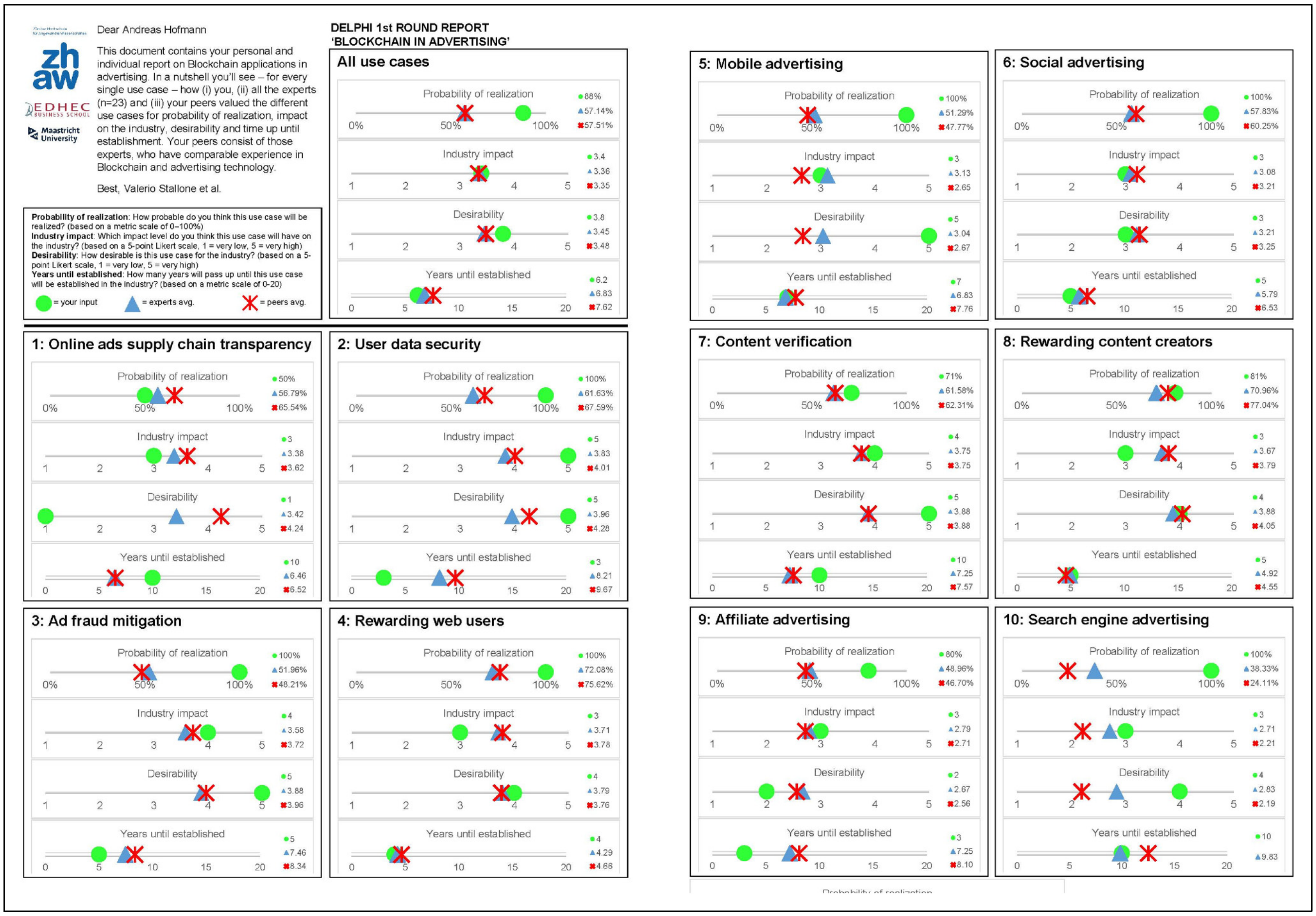

Figure A1. First-Round Report (R1/R2) for Delphi Panelists.

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