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Research Article

# Smart Contracts and Digital Transformation in Financial Services: A Systematic Review with Bibliometric Analysis and Scientific Mapping

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**ABSTRACT**
This study aims to analyze the scientific literature on the relationship between smart contracts and digital transformation in financial services, particularly in FinTech, banking, and insurance. Theoretically, it is grounded in the premise that financial digital transformation is a multidimensional process in which distributed infrastructures, contractual automation, regulatory governance, data security, and new forms of financial intermediation converge. Methodologically, the research was conducted as a systematic literature review following the PRISMA 2020 protocol, using Scopus as the sole database and integrating bibliometric analysis, science mapping, and natural language processing. The final corpus consisted of 84 open-access studies published in English. The findings reveal a recent and expanding field, characterized by sustained growth in scientific output, international collaboration, and progressive thematic diversification. It is concluded that smart contracts have moved beyond their understanding as merely a technical application of blockchain and are now established as mechanisms capable of transforming intermediation, traceability, compliance, governance, and trust within digital financial ecosystems.

**Keywords:** Digital Transformation, Financial Services, Fintech, Science Mapping, Smart Contracts, Systematic Review.

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## INTRODUCTION

The digital transformation of financial services has become one of the most significant forces reshaping contemporary banking, FinTech, and insurance, as it affects not only the technological infrastructure of transactions but also the ways agreements are recorded, validated, monitored, and executed across increasingly digitalized ecosystems. Within this context, smart contracts have gained strategic relevance because they enable the automation of contractual commitments, reduce operational frictions, enhance traceability, and strengthen the verifiability of critical processes. These attributes are especially valuable in financial activities, where trust, data security, contractual timing, and regulatory compliance play a decisive role.

The relevance of the study's core variables lies precisely in this convergence. On the one hand, digital transformation in financial services reflects a broader organizational, operational, and regulatory shift in which business models, intermediation mechanisms, and control systems are being redefined. On the other hand, smart contracts represent a hybrid legal-technological mechanism capable of executing programmable rules in real time, supporting conditional payments, enabling automated insurance processes, verifying collateral arrangements, reinforcing auditability, and contributing to new architectures of digital trust. As reflected in the literature, their potential extends beyond technical efficiency to encompass governance, security, compliance, and sustainability, which explains their growing prominence within digital financial ecosystems.

Despite the rapid expansion of this field, a significant knowledge gap remains. The screening and eligibility stages of the review revealed that many studies addressed smart contracts primarily from technical or programming-oriented perspectives, without explicitly linking them to broader processes of digital transformation in financial services. This suggests that the available evidence remains fragmented, with dispersed emphases

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across blockchain, automation, regulation, innovation, banking, insurance, and FinTech. Consequently, there is still a need for an integrative perspective capable of explaining the evolution of the field, its conceptual linkages, its thematic clusters, and its emerging research trajectories. In addition, the incorporation of natural language processing highlights the need to determine whether the existing literature has mainly prioritized technical dimensions, organizational applications, or deeper transformations in business models and service delivery.

The findings further reinforce the relevance of examining this gap. The final corpus of 84 studies indicates that this is a recent, active, and expanding line of inquiry, characterized by sustained growth in scientific output, a high degree of international collaboration, and increasing diversification of keywords, all of which point to a conceptual structure that is still consolidating. At the same time, the field appears to have evolved from a phase of rapid expansion toward a stage of relative maturity, showing signs of scientific consolidation rather than mere early emergence. This pattern confirms that a sufficient critical mass of academic production already exists to support systematic examination, while also indicating the need for greater intellectual organization to identify patterns, unresolved gaps, and future directions for research.

From a sustainable development perspective, this study is also aligned with the Sustainable Development Goals (SDGs). More specifically, it relates to SDG 8 by contributing knowledge on technologies that may improve the efficiency, innovation, and competitiveness of financial services; to SDG 9 through its emphasis on digital infrastructure, technological innovation, and process modernization; and to SDG 16 insofar as smart contracts are associated with transparency, traceability, programmable compliance, and the strengthening of institutional trust mechanisms. In addition, the field's growing orientation toward sustainability, smart banking, security, interoperability, and digital governance suggests that these technologies do not merely transform operations, but may also contribute to more resilient, verifiable, and inclusive financial ecosystems.

Accordingly, the study is justified by the need to develop a structured, reproducible, and analytically robust understanding of the current state of knowledge on smart contracts and digital transformation in financial services. Given the interdisciplinary, recent, and expanding nature of this body of literature, it is necessary to identify how scientific production has evolved, what its main thematic foci are, which conceptual relationships predominate, and where emerging trends are heading. This need supports the use of a systematic literature review based on the PRISMA 2020 protocol, combined with bibliometric analysis, science mapping, and natural language processing, since this methodological integration makes it possible to move beyond a purely descriptive account of publications toward a deeper understanding of the intellectual structure of the field.

Against this backdrop, the aim of this study is to systematically analyze the scientific literature on the relationship between smart contracts and digital transformation in financial services, particularly in FinTech, banking, and insurance, in order to identify the evolution of knowledge, the main thematic clusters, the conceptual connections, and the emerging trends that define this field of research.

## METHODOLOGY

This study employed a systematic literature review design with a quantitative orientation, aimed at examining the scientific production on smart contracts and digital transformation in financial services, particularly in FinTech, banking, and insurance. The methodological approach combined bibliometric analysis, science mapping, and natural language processing to identify the evolution of the field, its thematic structure, conceptual linkages, and emerging research trends.

The review process was guided by the PRISMA 2020 framework, ensuring transparency, reproducibility, and traceability throughout the identification, screening, eligibility, and inclusion stages. Scopus was selected as the sole source of information due to its broad multidisciplinary coverage, academic prestige, and the quality and consistency of its indexed metadata, which are particularly suitable for bibliometric and text-based analyses. The use of a single database also contributed to corpus homogeneity and reduced inconsistencies associated with cross-database duplication. However, the exclusive use of Scopus also represents a methodological limitation, as relevant studies indexed in other databases such as Web of Science, IEEE Xplore, ScienceDirect, or specialized legal and financial repositories may not have been captured. Therefore, the findings should be interpreted as representative of the Scopus-indexed literature rather than of the entire body of research on smart contracts and digital transformation in financial services.

The search strategy was constructed around the terms *"smart contract"* and *"smart-contract"*, combined with *"digital transformation"*, *"digitalization"*, *"digitization"*, and *"digital innovation"*. Searches were conducted in the title, abstract, and keywords fields. The initial retrieval yielded 835 records. Successive filtering procedures were then applied by language, document type, open-access status, and subject area. First, the dataset was restricted to English-language publications, resulting in 800 records. Second, only articles and review articles were retained, reducing the corpus to 323 documents. Third, the open-access criterion was applied, narrowing the sample to 209 studies. Finally, subject areas relevant to the research scope were selected, including computer science, social sciences, business, economics, mathematics, and decision sciences, which resulted in a final corpus of 84 studies.

This sequence was also represented in the PRISMA flow diagram to ensure consistency between the methodological description and Figure 1. Each exclusion stage was based on explicit criteria: language, document type, open-access status, and thematic alignment with the subject areas relevant to smart contracts, digital transformation, and financial services.

During the PRISMA-based screening and eligibility process, documents were excluded according to explicit methodological and thematic criteria (Table 1). Records were removed when they did not meet the predefined language, document type, open-access, or subject-area requirements. In addition, studies were excluded when their titles, abstracts, or keywords did not explicitly address the relationship between smart contracts and digital transformation in financial services. Documents focused exclusively on programming, coding architecture, cryptographic protocols, or purely technical blockchain issues were also excluded when they did not engage with broader organizational, operational, strategic, regulatory, or innovation-related dimensions of digital transformation. Therefore, the final sample comprised 84 open-access studies published in English and directly aligned with the purpose of the review.

Once the corpus was finalized, the bibliographic records were exported from Scopus and processed in R-Studio for cleaning, normalization, and analytical preparation. This stage included verification of bibliographic integrity, treatment of missing values, standardization of author names, journal titles, and keywords, correction of orthographic and encoding inconsistencies, and removal of non-informative symbols. Although the use of a single database substantially reduced duplication, the dataset was also checked for logical duplicates derived from minor indexing variations.

For the natural language processing stage, the textual corpus was built from titles, abstracts, and keywords. The preprocessing workflow included lowercasing, punctuation removal, stop-word elimination, lexical normalization, tokenization, and term consolidation in order to reduce semantic dispersion and improve analytical consistency. Where required, lemmatization procedures were also applied to group semantically equivalent terms and strengthen the interpretation of thematic patterns.

The analytical strategy was structured in two complementary layers. First, the bibliometric analysis examined publication trends, scientific productivity, source distribution, and subject-area concentration, thereby providing an overview of the field's development. Second, science mapping and natural language processing were used to identify conceptual relationships, recurrent terms, semantic associations, and thematic clusters. This integrated design enabled a deeper understanding of how the literature articulates smart contracts with blockchain, automation, digital innovation, financial intermediation, regulatory dynamics, and operational efficiency.

Overall, the methodological rigor of the study rests on the combined use of PRISMA 2020, a carefully delimited and homogeneous Scopus-based corpus, systematic data cleaning in R-Studio, and the integration of bibliometric and semantic techniques. This design not only supports the descriptive examination of scientific production but also enables a more robust interpretation of the intellectual structure and developmental trajectory of the field.

From an ethical standpoint, this study was framed as documentary research and therefore did not involve interaction with human participants or the use of sensitive personal data. Accordingly, no direct risks to human subjects were identified. Nevertheless, principles of scientific integrity were upheld throughout all stages of the research process, ensuring transparency in the search, selection, exclusion, and treatment of information. The use of R-Studio was limited to the organization, cleaning, and analysis of metadata and scientific texts, without altering the original content of the documents or compromising source fidelity. In this way, the study adhered to the principles of traceability, reproducibility, and responsible use of academic information.

In summary, the methodological procedure followed a rigorous sequence that began with the conceptual delimitation of the topic, continued with the formulation and application of Boolean search equations in Scopus, advanced through the systematic selection of studies under the PRISMA 2020 protocol presented in Figure 1, and concluded with the cleaning, bibliometric analysis, science mapping, and natural language processing of the final corpus of 84 documents. This procedure made it possible to construct a structured, reproducible, and analytically robust understanding of the state of knowledge on *Smart Contracts and Digital Transformation in Financial Services (FinTech, Banking, and Insurance): A Bibliometric and Science Mapping Study*, thereby providing a consistent methodological foundation for the interpretation of findings and the projection of future research avenues.

## RESULTS

Figure 2 summarizes the main bibliometric indicators of the analyzed corpus and provides an overview of scientific production on smart contracts and digital transformation in financial services. The results show that the final dataset consists of 84 open-access documents published in English and indexed in Scopus, confirming the existence of a delimited but analytically relevant body of literature for systematic and bibliometric examination. These indicators provide the initial empirical basis for interpreting the evolution, structure, and thematic configuration of the field.

Overall, the bibliometric indicators suggest that this is a recent and expanding research domain. The volume of publications reflects growing academic interest in the relationship between smart contracts, blockchain-based infrastructures, and the

digital transformation of financial services. This growth is consistent with the increasing relevance of FinTech, InsurTech, RegTech, digital payments, programmable compliance, and data-driven financial ecosystems. Therefore, the analyzed production indicates that smart contracts are no longer treated only as a technical component of blockchain, but increasingly as mechanisms associated with automation, transparency, traceability, governance, and institutional trust.

The distribution of sources, authors, countries, and keywords also reveals the interdisciplinary nature of the field. The literature combines contributions from computer science, business, economics, social sciences, decision sciences, and related areas, showing that the topic cannot be understood from a purely technological perspective. Instead, the bibliometric profile confirms that smart contracts operate at the intersection of technological innovation, financial intermediation, regulatory transformation, data security, and organizational change. This interdisciplinary configuration supports the methodological decision to combine bibliometric analysis, science mapping, and natural language processing.

In addition, the indicators shown in Figure 2 suggest that the field is moving toward a stage of scientific consolidation. Although the corpus remains relatively compact, the diversity of thematic descriptors and publication outlets shows that the discussion has expanded beyond blockchain and cryptocurrency toward broader applications in digital finance, auditing, insurance, sustainability, supply chain traceability, and regulatory governance. Accordingly, Figure 2 provides a general bibliometric foundation for the subsequent analyses of scientific production over time, country-author-theme relationships, source evolution, keyword co-occurrence, and thematic clustering.

Figure 3 illustrates the evolutionary trajectory of scientific production in the analyzed field through a life-cycle model, making it possible to interpret not only its historical growth but also its degree of maturity and future projection. Overall, the findings indicate that the topic has undergone a phase of accelerated expansion and is now approaching a stage of consolidation. This interpretation is supported by the estimated saturation level of 100 publications and by the identification of 2024 as the peak year, with a maximum output of 19 publications, suggesting that the field's greatest dynamism is concentrated in a recent period.

The model fit provides further support for this interpretation. The value of $R^2 = 0.735$ indicates an acceptable explanatory capacity for describing the growth trajectory of scientific production, while the complementary error and penalty indicators suggest a moderate fit, sufficient for examining the field's general trends. From this perspective, the scientific output does not appear to be in an initial or incipient phase, but rather in a more advanced stage in which growth continues, although with signs of progressive deceleration.

This trend is reinforced by the observed progress toward saturation, estimated at 84.0%, together with the cumulative total of 84 publications by the last year of observation, corresponding to 2026. In bibliometric terms, this result suggests that the field has already developed a critical mass of knowledge and that its future expansion is likely to be more selective than explosive. The logic of the model itself indicates that the topic is situated in a maturity phase, particularly around the 50% saturation threshold, reached approximately in 2024.3, after which the growth rate begins to moderate. Thus, rather than indicating a loss of relevance, the evidence points to a transition from an emergent stage to one of scientific consolidation.

The key years identified by the model further reinforce this reading. The point corresponding to 90% of K is projected for 2027.1, while 99% saturation is estimated for 2030.3. This suggests that although the field still has room for expansion, its future trajectory will be less intensive in terms of volume and more oriented toward theoretical, methodological, and applied deepening. This pattern is characteristic of scientific domains that, after a period of rapid growth, begin to stabilize their research agendas, academic communities, and principal lines of debate.

The prospective component of the graph strengthens this interpretation. For the 2027-2051 period, the model anticipates an almost stable cumulative trajectory, with 99 publications by 2031 and 100 publications by 2036, indicating that residual growth will be minimal. Consequently, the evidence does not point to thematic exhaustion, but rather to the stabilization of the field, in which new contributions are likely to concentrate on more specialized niches, more sophisticated debates, and more specific applications. In this sense, Figure 3 supports the conclusion that the analyzed scientific production has moved beyond its initial emergence phase and has entered a stage of relative maturity,

**Table 1: PRISMA-based screening and eligibility criteria.**

| Stage | Criterion applied | Records retained | Records excluded |
|---|---|---|---|
| Identification | Initial retrieval from Scopus | 835 | — |
| Screening 1 | English-language publications | 800 | 35 |
| Screening 2 | Articles and review articles | 323 | 477 |
| Screening 3 | Open-access publications | 209 | 114 |
| Eligibility | Relevant subject areas | 84 | 125 |

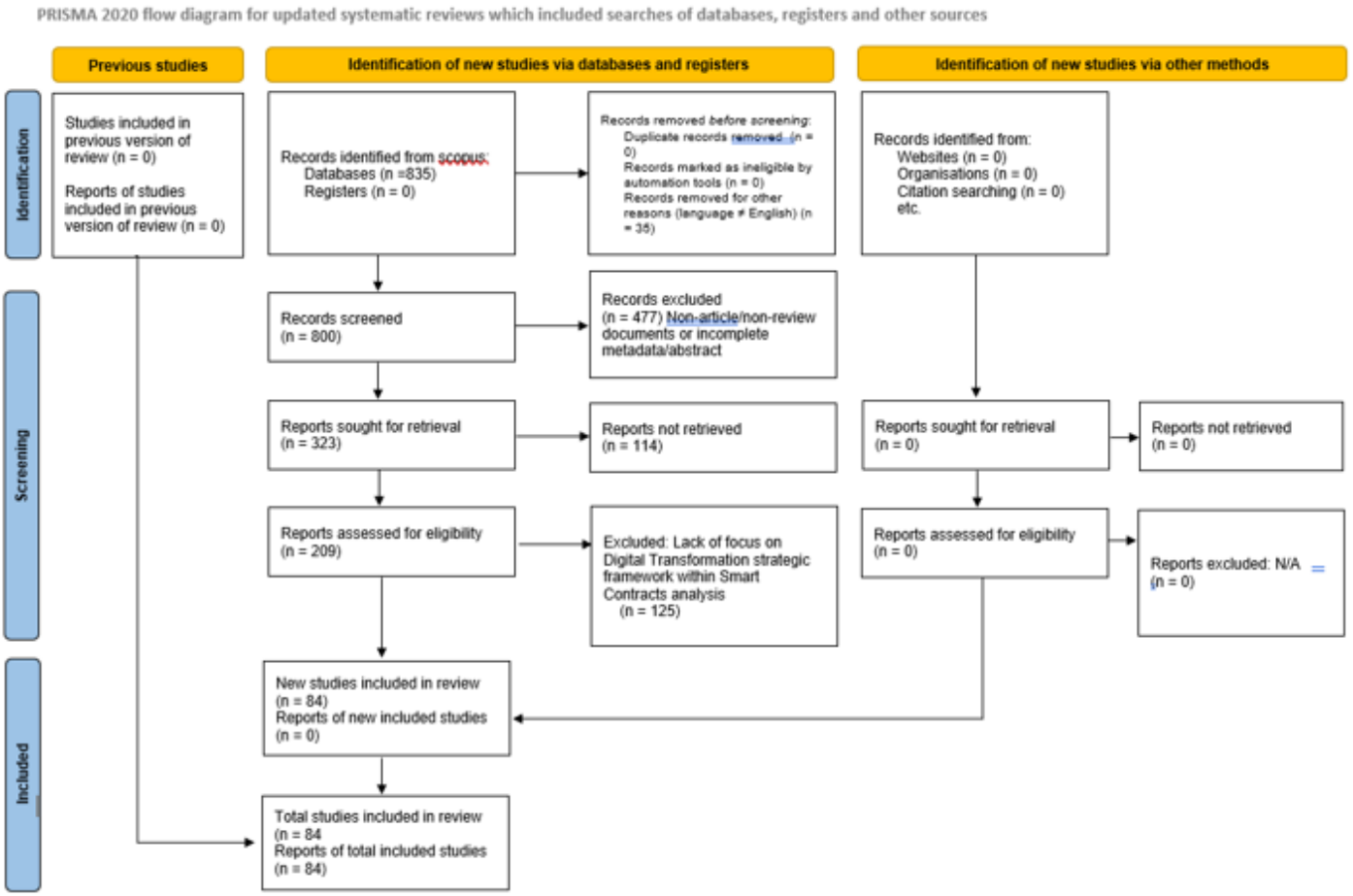



**Figure 1:** PRISMA-based search and selection strategy for the systematic review.

characterized by strong recent visibility, expected deceleration, and the progressive consolidation of its intellectual structure.

Figure 4 presents the temporal evolution of scientific production from two complementary perspectives: the annual pattern of publications and the cumulative growth curve. The left panel shows a sharp increase in output, reaching a peak of 19 publications in 2024.3, followed by a projected gradual deceleration. This pattern suggests that the field experienced a phase of rapid expansion in recent years and is now approaching a stage of maturity in which quantitative growth begins to stabilize.

The right panel confirms this trend through a sigmoid-shaped cumulative curve, with an estimated saturation level of 100 publications. The proximity of the observed volume to this threshold indicates that the field has reached a critical mass of scientific production and that future contributions are likely to grow at a more moderate pace. Taken together, Figure 4 shows that the analyzed topic has consolidated its presence within the scientific literature and that its future development will be more closely associated with the deepening and specialization of knowledge than with a continued rapid increase in publication output.

From a bibliometric perspective, this pattern is consistent with research areas that, after a period of rapid positioning, begin to stabilize their thematic agendas, analytical approaches, and collaboration networks. In this sense, the projected deceleration should not be interpreted as a loss of relevance, but rather as an indication of field consolidation, in which future production will likely be oriented toward more specific, rigorous, and applied contributions within the scientific development of the area.

## Countries, Authors, and Source Production

Figure 5 depicts the relational structure among countries of affiliation, authors, and thematic descriptors, making it possible to identify how scientific production in the field is articulated from geographical, authorship, and conceptual perspectives. Overall, the graph shows that the analyzed literature is not distributed homogeneously; rather, it is concentrated in specific countries and around certain authors who function as visible nodes within the network. In this regard, Romania, China, and India stand out as relevant countries of origin, suggesting that these national contexts play an active role in shaping the scientific debate on the topic under study.

From the authorship dimension, the figure shows that certain researchers maintain clearer connections with the main research axes, which suggests a more visible contribution to the thematic consolidation of the field. Authors such as Bizon, Nicu; Enescu, Florentina Magda; Thounthong, Phatiphat; Peng, Xiangzhen; and others represented in the network appear linked to different descriptors, revealing that scientific production is organized around specific contributions that connect institutional affiliation with conceptual specialization. This pattern is consistent with fields in consolidation, where a relatively delimited group of scholars begins to acquire centrality within the academic conversation.

At the thematic level, the descriptors located on the right side show that the main research lines are oriented toward concepts such as *blockchain, smart contract, COVID-19, supply chain management*, and *detection method*. The presence of these terms suggests that the field is not confined to a strictly technological discussion, but rather incorporates diverse applications associated with management, traceability, automation, and responses to disruptive contexts. In particular, the recurrence of *blockchain* and *smart contract* confirms that these concepts function as the core organizing nodes of the field, while the appearance of terms related to supply chains or detection methods reflects the applied and interdisciplinary expansion of the literature.

Taken together, Figure 5 suggests that the intellectual structure of the field is supported by an international production network in which specific countries and authors channel the main contributions toward well-defined conceptual axes. Rather than reflecting a fragmented distribution, the graph reveals a relational organization in which scientific geography, authorship, and research themes converge around specific knowledge hubs. From a bibliometric perspective, this pattern is characteristic of areas that have begun to stabilize their research communities and thematic agendas, moving from an exploratory phase toward a stage of greater specialization and academic consolidation.

Figure 6 illustrates the temporal evolution of the most representative publication sources within the analyzed corpus, making it possible to identify which journals or editorial outlets have maintained a more consistent presence in disseminating knowledge on the topic under study. Overall, the graph reveals a marked concentration around one dominant source, whose cumulative trajectory grows steadily from 2020 to 2026, well above the rest. This pattern suggests that scientific production is not only dispersed across multiple journals, but also characterized by certain editorial hubs with greater capacity for thematic continuity and scholarly visibility.

Within this dynamic, *Sustainability* (Switzerland) stands out in particular, as it records the highest cumulative frequency in the database and maintains a sustained presence throughout almost the entire observation period. Its progressive growth indicates that this source has functioned as one of the principal visibility channels for the field, likely due to its openness to interdisciplinary research related to innovation, digitalization, sustainability, and the transformation of productive and financial systems. From a bibliometric perspective, the centrality of this journal reflects how certain editorial spaces become consolidated as key reference points for the scientific discussion of emerging topics.

In contrast, the remaining sources display more moderate and recent trajectories, with cumulative increases of smaller magnitude. Journals such as *Financial and Credit Activity: Problems of Theory and Practice* and *Indian Journal of Information Sources and Services* show a visible, although more limited, presence, while others such as *Technovation, ISPRS International Journal of Geo-Information*, and *Foods* contribute more sporadically in specific years. This pattern suggests that, although editorial diversity exists, a substantial portion of the contributions is still distributed in a fragmented manner and with uneven levels of continuity, which is characteristic of fields undergoing consolidation.




**Figure 2:** Bibliometric indicators.

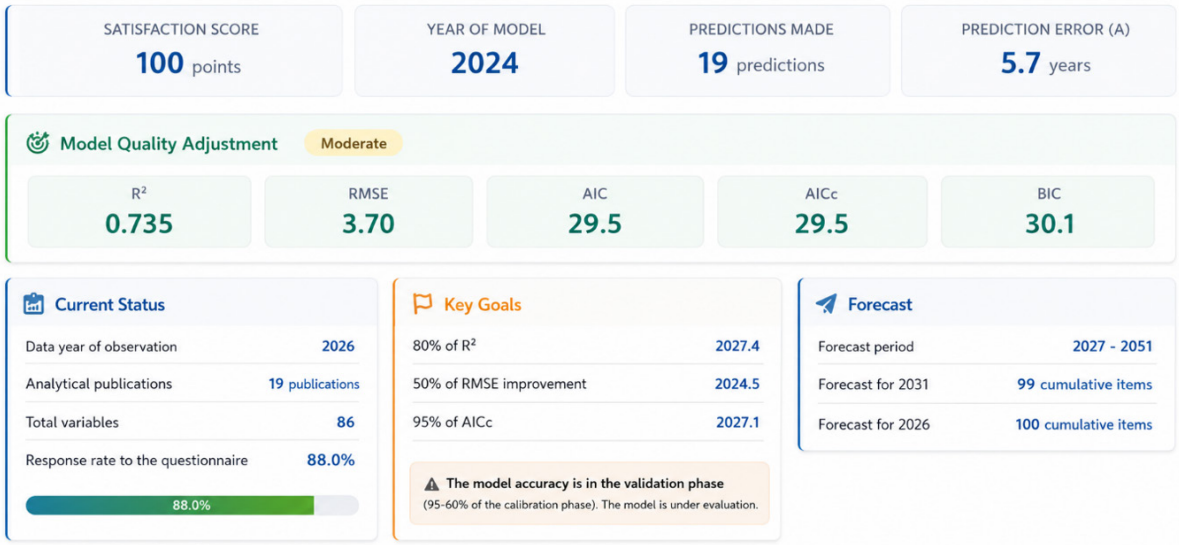



**Figure 3:** Scientific Production Life Cycle.

Taken together, Figure 6 suggests that the editorial structure of the field combines two simultaneous features: on the one hand, a clearly dominant source that concentrates a significant share of total production; on the other, a set of secondary journals that broaden the discussion through specific and complementary perspectives. This configuration is consistent with recent research areas in which thematic expansion has not yet translated into a homogeneous distribution across journals, but rather into a relative concentration in certain publication channels that lead the dissemination of knowledge. Thus, the graph not only shows the evolution of sources over time, but also provides evidence regarding the editorial maturity of the field and the outlets that currently function as central platforms of scientific legitimation.

## Conceptual structure and thematic evolution

Figure 7 depicts the conceptual structure of the field through a keyword co-occurrence network. The most central node is *blockchain*, closely accompanied by *smart contract* and *smart contracts*, confirming that these terms constitute the dominant thematic core of the literature. The strength of their connections suggests that the field has been organized primarily around the study of blockchain as a technological infrastructure and of smart contracts as one of its most relevant applications within processes of automation, digital trust, and traceability.

Around this central core, additional thematic clusters can be identified. On the one hand, terms associated with digital transformation and information management emerge, such as *digitization, blockchain technology, innovation*, and *data management*; on the other hand, descriptors related to sustainability and supply chains are also visible, including *sustainability, supply chain, traceability*, and *transparency*. Taken together, Figure 7 shows that the literature is not confined to a purely technical understanding of the technology, but has evolved toward a broader, more interdisciplinary, and more applied perspective, in which blockchain and smart contracts are linked to multiple organizational, productive, and managerial contexts.

Figure 8 presents the thematic map of the analyzed corpus based on the levels of centrality and density of the main conceptual clusters, making it possible to identify not only which topics occupy a more strategic position within the field, but also their degree of internal development. Overall, the graph reveals a relatively consolidated thematic structure in which motor themes, basic themes, niche themes, and emerging or declining themes coexist. This configuration suggests that the literature has reached an important level of conceptual diversification while maintaining a clearly defined core articulated around *blockchain, smart contracts*, and digital transformation.

In the quadrant of motor themes, clusters such as *sustainability, decentralization*, and *supply chain management*, together with *digitization, innovation*, and *digital innovations*, are positioned. Their location in the upper-right area indicates that they combine high centrality and high density; that is, they are not only well developed internally, but also play a significant role in structuring the field. This suggests that recent literature has directed a substantial share of its attention toward blockchain and smart contract applications related to sustainability, decentralization, supply chain management, and digital innovation, confirming a thematic expansion that goes beyond a strictly technical perspective.

In the quadrant of basic themes, the cluster formed by *smart contracts, blockchain technology*, and *digital transformation* appears with high centrality but comparatively lower density. This position suggests that it constitutes a fundamental core for the organization of the field, strongly connected to other research lines, yet still undergoing internal development. From a bibliometric perspective, this pattern is consistent with concepts that function as the structural foundation of the literature,

articulating multiple debates and applications without necessarily forming a fully closed or highly specialized theme. In this sense, digital transformation associated with blockchain and smart contracts emerges as one of the backbone dimensions of the domain under analysis.

A more intermediate position is occupied by the cluster composed of *blockchain, smart contract*, and *cryptocurrency*, located near the center of the map. This placement reflects a balance between relevance and development, which may be interpreted as evidence of its transversal role within the field. Rather than representing a marginal line of inquiry, this group functions as a transitional core between structural themes and specialized applications, serving as a conceptual basis for a substantial portion of the scientific production examined. Similarly, the cluster composed of *digitalization, FinTech*, and *artificial intelligence* shows moderate relevance together with appreciable conceptual development, suggesting an expanding thematic line that links decentralized technologies with broader processes of financial innovation and intelligent automation.

By contrast, the lower-centrality quadrants include themes such as *energy efficiency* and *blockchain governance*, located in the area of emerging or declining themes, as well as the cluster *block-chain, distributed ledger*, and *data privacy*, situated within the niche-theme space. This distribution indicates that certain lines of research, although specialized and potentially relevant, have not yet reached a structural weight comparable to that of the field's central themes. In some cases, this may reflect an incipient stage of development; in others, a weaker integration with the core debate. Taken together, Figure 8 shows that the thematic structure of the field is organized around a consolidated core linked to *blockchain, smart contracts*, and digital transformation, while its extensions toward sustainability, innovation, governance, and privacy display different levels of maturity and future projection.

Figure 9 presents a dendrogram derived from factor analysis, designed to identify the conceptual proximity among the most representative terms in the corpus and, in doing so, reveal the hierarchical structure of the field of study. Overall, the graph shows that the literature is not organized around isolated and independent concepts, but rather through progressive groupings that reflect thematic affinities and co-occurrence relationships among keywords. This configuration makes it possible to observe how certain terms become associated at early stages, forming more compact conceptual cores, while others are integrated at higher levels, resulting in a broader and more articulated thematic structure.

On the left side of the dendrogram, close associations can be identified among terms such as *blockchain, cryptocurrency, accounting*, and *smart contract*, suggesting that part of the literature has developed around the financial, accounting, and transactional applications of decentralized technologies. The proximity among these concepts indicates a strong relationship within the corpus, especially in studies linking blockchain to accounting records, digital assets, and the automation of agreements. This cluster confirms that the financial and technological dimension constitutes one of the most recognizable foundations of the field under analysis.

Toward the central area of the graph, an articulation emerges among terms such as *supply chain management, blockchain technology, regulation, digital transformation, internet of things, FinTech, digitalization, artificial intelligence, smart contracts*, and *construction industry*. This grouping shows that the literature has evolved from an approach focused exclusively on technology

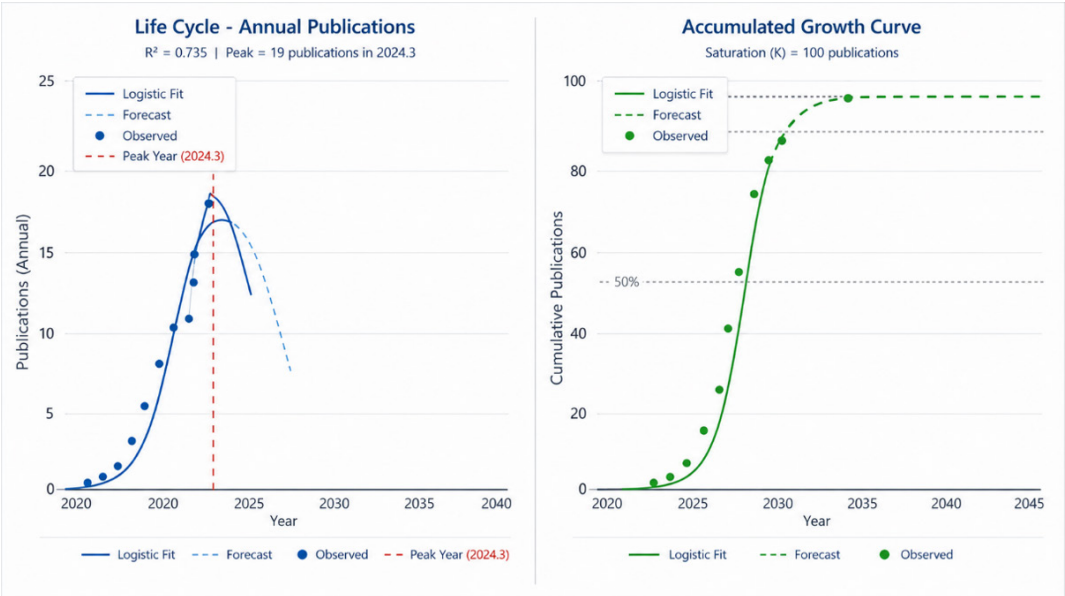



**Figure 4:** Annual Trajectory and Cumulative Growth of Scientific Production.

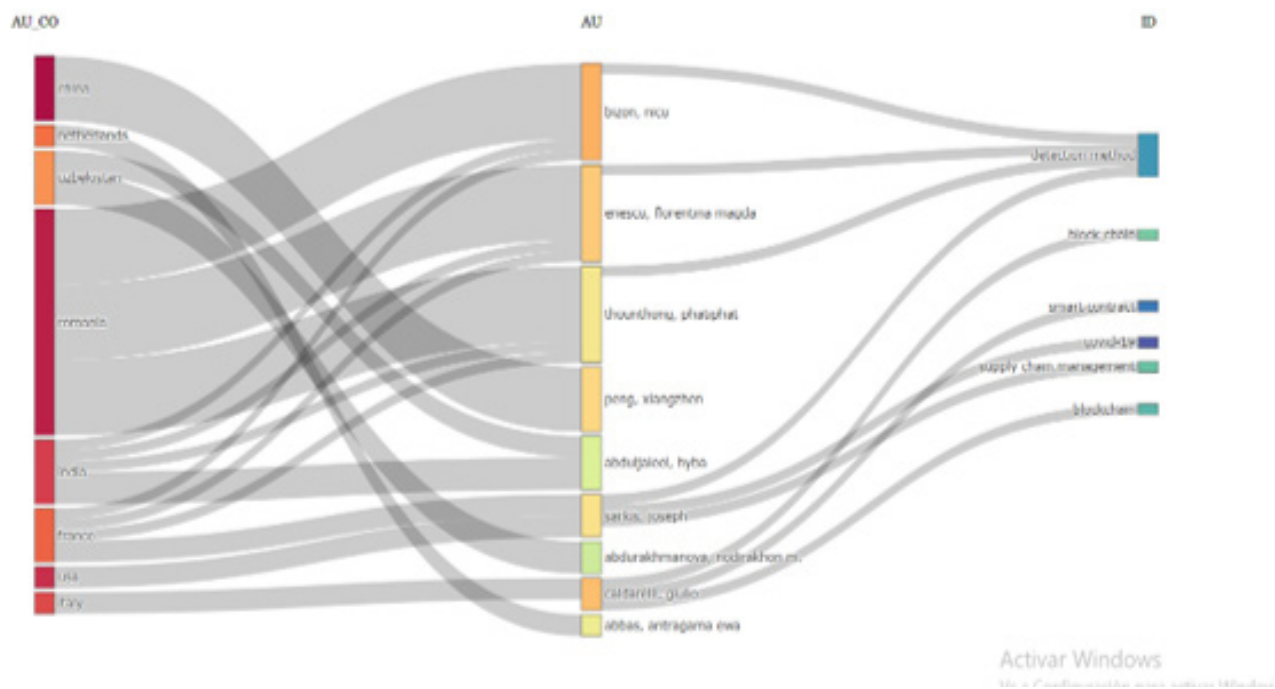



**Figure 5:** Relationship Between Countries, Authors, and Thematic Research Lines.

toward a more applied and interdisciplinary perspective, in which blockchain and smart contracts are connected with processes of digital transformation, automation, regulation, and integration with other emerging technologies. From a bibliometric perspective, this cluster reveals that the field has expanded its conceptual boundaries and incorporated diverse sectors and analytical frameworks.

On the right side of the dendrogram, terms such as *industry 4.0, transparency, decentralization, sustainability, chain management, supply chain, healthcare, circular economy*, and *security* are more strongly concentrated. The proximity among these descriptors indicates a growing orientation toward sectoral and organizational applications, particularly around sustainability, traceability, security, and systemic efficiency. This pattern suggests that recent literature does not examine blockchain merely as a digital infrastructure, but also as a mechanism with the potential to improve complex processes in productive, logistical, and social contexts. The integration of concepts such as sustainability and circular economy further reinforces the expansion of the field toward contemporary debates of high academic relevance.

Taken together, Figure 9 shows that the intellectual structure of the corpus is hierarchical and multidimensional, with an initial core centered on *blockchain* and *smart contracts* that subsequently expands toward domains such as FinTech, digital transformation, supply chains, sustainability, and security. This organization confirms that the field has reached an important level of conceptual diversification while maintaining internal coherence around decentralized technologies and their applications. Thus, factor analysis not only makes it possible to identify affinities among terms, but also to understand how the literature has evolved from a foundational technological focus toward a broader, more applied, and more interdisciplinary research agenda.

## Author Content Analysis by Thematic Domains

### *Digital transformation and financial intermediation*

Digital transformation in financial services constitutes one of the most significant processes of economic and institutional reconfiguration in recent decades, as it not only modifies service delivery channels, but also reshapes the technological, regulatory, and operational architecture on which markets are built. In this context, the digitalization of the monetary and financial system has fostered new forms of interaction among technology, value, and governance. From this perspective, Gavrílova (2021) explains that the evolution of money in digital environments requires a reconsideration of the foundations of the contemporary monetary system, while Sarnakov (2019) argues that digital financial assets have begun to consolidate as a category with distinct legal and economic implications. In a convergent line, Tonkykh *et al.* (2023) point out that blockchain has driven the transition toward more decentralized and innovative financial infrastructures, while Teng *et al.* (2026) emphasize that the expansion of digital assets must be analyzed alongside their risks, mitigation mechanisms, and control requirements. Taken together, these contributions make it possible to understand that the digital transformation of financial services is not merely an instrumental shift, but rather a systemic reconfiguration of exchange, recordkeeping, and trust processes.

## FinTech Adoption, Trust, and Sustainable Finance

The consolidation of emerging financial technologies also depends on factors associated with acceptance, trust, and perceived usefulness among users, organizations, and institutions. In this regard, Awale and Kulmie (2024) show that awareness and understanding of FinTech innovations are fundamental drivers of effective adoption, especially in contexts where digital maturity remains uneven. Complementarily, Georgiev (2024) argues that the rise of FinTech does not necessarily imply the disappearance of financial intermediation, but rather its reformulation within hybrid schemes of competition and collaboration with traditional banking. This discussion is reinforced by Jabbar *et al.* (2023), who show that the acceptance of central bank digital currencies is shaped by perceptions of privacy, legitimacy, and usefulness, while Khalegi *et al.* (2024) highlight that blockchain can strengthen financial sustainability by improving the transparency of green investments. These contributions suggest that smart contracts should be analyzed as instruments embedded in an ecosystem of digital trust, where technological value only materializes when translated into institutional legitimacy and social acceptance.

## InsurTech, RegTech, and Regulatory Transformation

Within this process of change, financial innovation has begun to affect different subsectors in distinct ways, including banking, insurance, regulatory compliance, and institutional management. Hoffmann (2021) shows that, in the InsurTech domain, smart contracts can reshape entrepreneurship, product design, and the relationship with policyholders by automating contractual events and reducing operational frictions. In line with this, Abisheva *et al.* (2025) argue that the growing digitalization of insurance products requires new regulatory and legal responses capable of accompanying market transformation. In parallel, Grassi and Lanfranchi (2022) identify RegTech as a central component of the new digital financial environment, as it facilitates the alignment between technological innovation and regulatory compliance. Likewise, Bazeliuk *et al.* (2023) demonstrate that digitalization also affects the financial autonomy of complex organizations, confirming that financial transformation extends beyond commercial operations and reaches the very structure of management and governance. Therefore, the study of smart contracts in financial services must be situated within a broad perspective capable of integrating innovation, regulation, and organizational redesign.

## Legal Validity and Institutional Recognition of Smart Contracts

One of the most relevant foundations of the theoretical framework concerns the legal dimension of contractual automation, since smart contracts raise questions regarding validity, enforcement, liability, and institutional recognition. At this level, Djuraev *et al.* (2025) argue that digitalization is transforming the legal systems of developing countries and requires a rethinking of regulatory capacity in light of new forms of contracting and digital evidence. From a more specific perspective, Kulyk *et al.* (2024) maintain that decentralized autonomous organizations challenge traditional understandings of corporate and contract law by shifting decision-making functions toward coded rules. For their part, Giacalone and Arnone (2025) show that

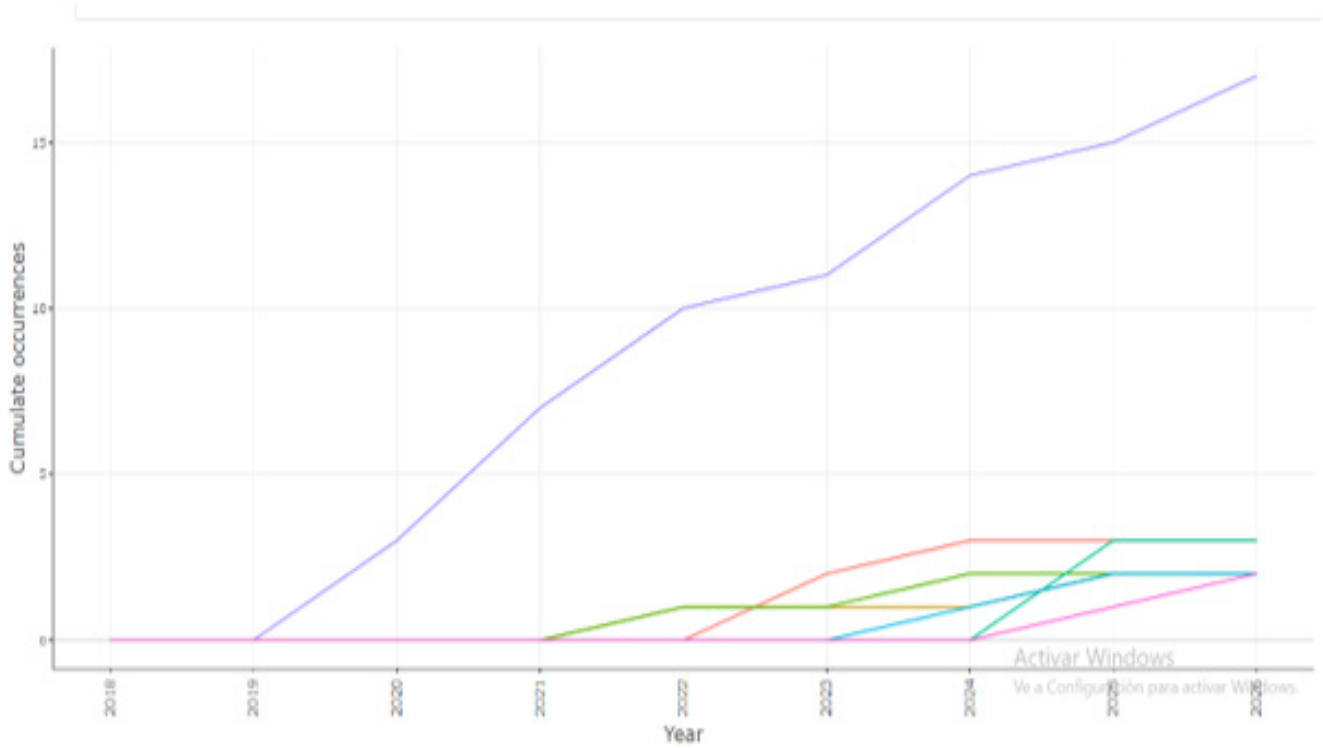



**Figure 6:** Source Production Over Time.

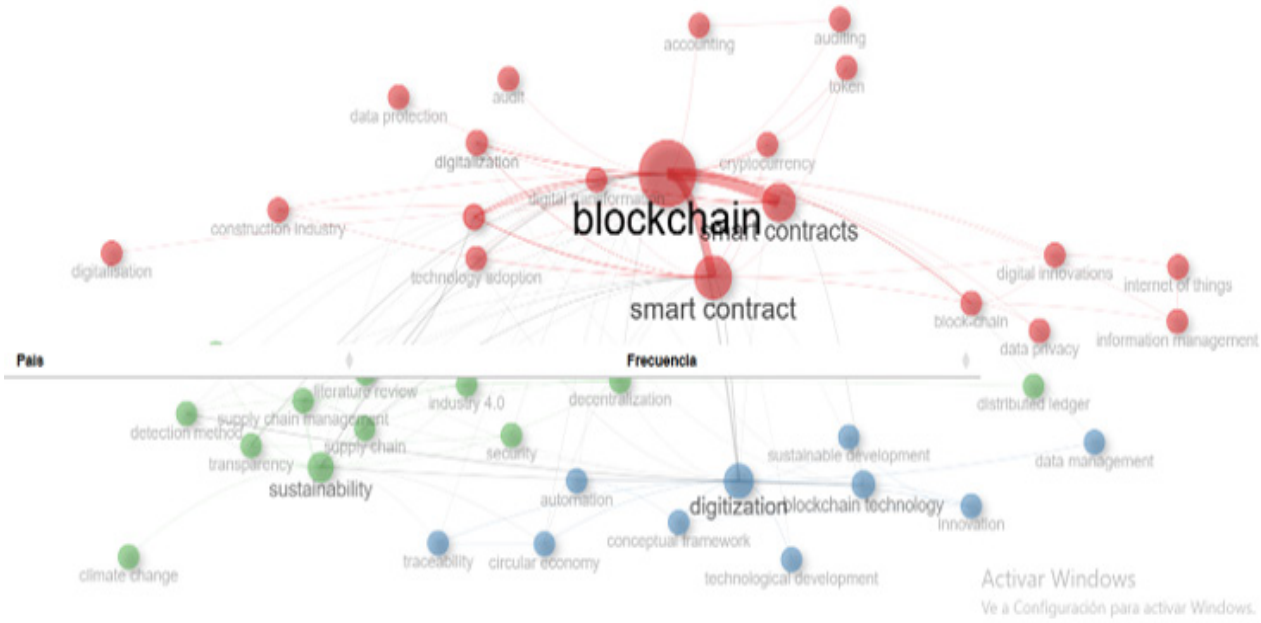



**Figure 7:** Term Co-occurrence Network.

blockchain can be applied to simplified judicial procedures, strengthening traceability, transparency, and efficiency, while van Erp and Zimmermann (2022) emphasize that documentary standardization and its progressive digitalization are necessary conditions for legal interoperability. These arguments are especially relevant in financial services, where smart contracts do not merely automate clauses, but reconfigure how evidence, compliance, and contractual supervision are understood.

## International Payments and Cross-Border Financial Transactions

The international dimension of digital financial services further reinforces the relevance of smart contracts, particularly in payments, trade, and cross-border transactions. Pečarić *et al.* (2020) demonstrate that blockchain and smart contracts can improve international payments by reducing execution times and operational asymmetries among intermediaries. Complementarily, Klym and Melnyk (2025) explain that these technologies hold considerable potential for automating international business activities, especially those that depend on documentary verification and predefined contractual sequences. This is further supported by Shevchenko *et al.* (2022), who relate the digitalization of trade to a reorganization of markets and business practices, while Bui (2026) extends the analysis to regional cooperation and public-private partnerships linked to the digital and green transition. Consequently, the literature supports the view that smart contracts enhance the efficiency of global financial relations by providing a programmable logic of compliance, verification, and trust among actors operating across jurisdictions.

## Accounting, Auditing, and Assurance Systems

Another central axis of the field concerns accounting, auditing, and assurance systems, in which blockchain has been studied as a tool capable of transforming the traceability of financial information. Larikova *et al.* (2023) argue that blockchain technology strengthens accounting and analytical support systems by ensuring greater consistency in records and validation processes. In the same direction, Matskiv *et al.* (2023) show that accounting and auditing are deeply influenced by the incorporation of distributed ledgers, requiring new technical competencies and new control models. From a more integrative review perspective, Lombardi *et al.* (2022) conclude that blockchain alters assurance practices, modifies the nature of evidence, and opens new research agendas around verification and trust. Similarly, Silva *et al.* (2022) confirm through a systematic and bibliometric review that blockchain auditing has begun to consolidate as a specific domain within the literature. This body of studies is particularly relevant for financial services, since the sector's digital transformation depends on the availability of verifiable, auditable, and transparent records.

However, the automation of accounting and financial processes does not eliminate risks; rather, it displaces them into new zones of technological and regulatory complexity. Oraby (2025) warns that the incorporation of blockchain into accounting and auditing substantially changes the nature of control and monitoring procedures. Likewise, Ivanchenkova *et al.* (2023) identify specific risks associated with the use of blockchain in auditing, highlighting the need to adapt assessment and review methodologies. From a tax perspective, Vishnevsky *et al.* (2020) show that digital technologies are also transforming

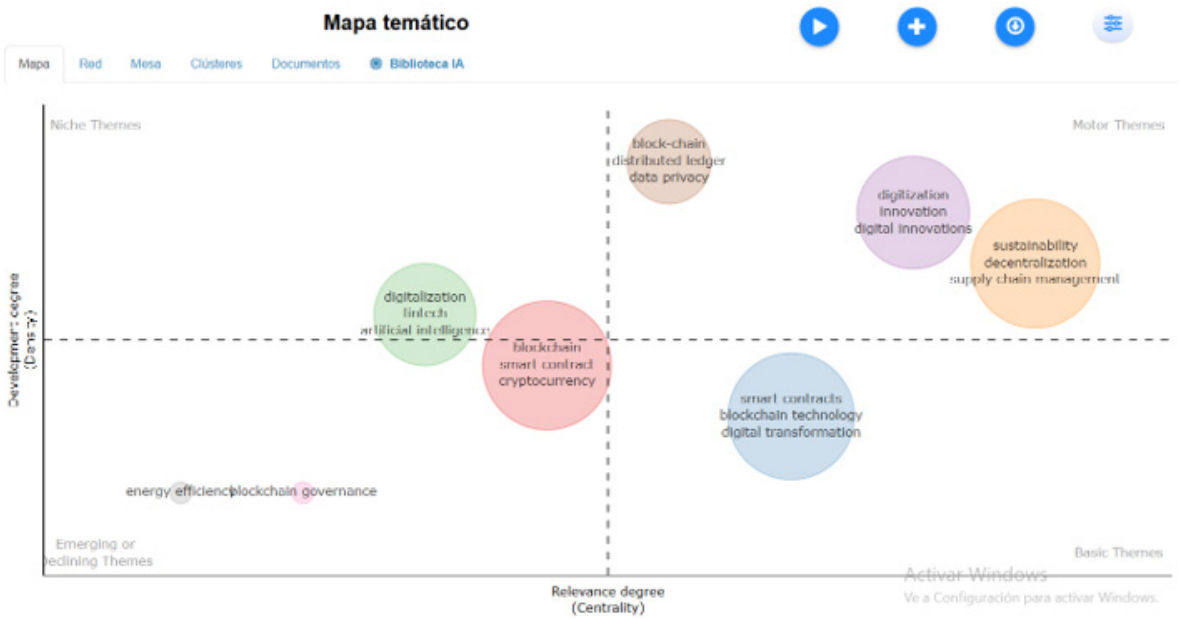



**Figure 8:** Thematic Map of the Field of Study.

fiscal systems, affecting revenue collection, supervision, and the administration of obligations. In turn, Bannikov *et al.* (2024) argue that blockchain- and smart contract-based automation can improve management sustainability, but only when integrated with robust control and monitoring mechanisms. In this sense, the literature suggests that digitalized financial services require governance frameworks capable of accompanying automation with effective supervision and risk mitigation capacities.

## Digital Identity, Cybersecurity, and Data Protection

Digital identity, access security, and data protection also emerge as fundamental pillars for the deployment of smart contracts in financial environments. Başer *et al.* (2023) demonstrate that blockchain-based identity can replace traditional documents and provide more secure and portable forms of validation. In a particularly sensitive application, Martínez *et al.* (2026) develop a secure identity framework for the healthcare sector, highlighting the need to balance agile access with information protection. In a complementary legal line, Alsamara and Farouk (2024) argue that digital transformation in sensitive systems requires specific legal frameworks to support its functioning and scalability. Finally, Mecias and Palaoag (2024) show through simulation that the security of smart contracts constitutes a critical factor when high-sensitivity data or assets are being managed. Although these studies do not come exclusively from the financial domain, they provide a strong theoretical basis for understanding that the expansion of digital financial services depends on trustworthy infrastructures of identity, authentication, and contractual security.

## Sustainability, Traceability, and Sectoral Governance

A significant part of the corpus also links blockchain with sustainability, traceability, and sectoral governance, elements that are conceptually transferable to the financial domain. Vilkov and Tian (2019) show that the technology can be used to combat illegal markets through distributed tracking and verification mechanisms. In the same line, Junchairussamee *et al.* (2025) highlight the strategic value of blockchain for the transformation of agricultural governance in developing economies, while Sukhetska *et al.* (2025) present the technology as a driver of change in the agro-industrial sector. Complementarily, Stanescu *et al.* (2025) relate digitalization, blockchain, and resilience in sustainability-oriented agri-food chains. These findings reinforce the idea that smart contracts not only automate processes, but also help structure new forms of interorganizational trust and traceability, which is particularly valuable for financial services such as payments, parametric insurance, green finance, and asset tracking.

The logic of coordination, monitoring, and automated execution has also been widely developed in the supply chain literature, one of the domains where blockchain has found the greatest practical application. Khanfar *et al.* (2021) argue that blockchain strengthens sustainable manufacturing and supply chain management by improving process visibility. Similarly, Bekrar *et al.* (2021) show that the digitalization of the logistics cycle benefits from distributed ledgers that connect transport and supply chains more efficiently. Rivera *et al.* (2024) interpret blockchain as an opportunity to reconfigure value chains under conditions of accelerated digitalization, while Nabipour and Ülkü (2021) explain that the pandemic intensified the search for logistics solutions based on transparency and resilience. This

theoretical set is highly relevant to financial services because it shows that contractual automation creates value when it reduces uncertainty, improves visibility, and coordinates multiple actors through shared rules.

More specifically, the literature demonstrates that blockchain and smart contracts improve transparency, supervision, and control capacity in complex exchange networks. Jannat *et al.* (2025) highlight that distributed ledgers strengthen supply chain efficiency, transparency, and security. In an applied contribution, Peng *et al.* (2022) present a cross-chain supervision model for the rice supply chain, illustrating the usefulness of smart contracts for coordinating multilevel control. Meanwhile, Masa'deh *et al.* (2024) connect digitalization, Industry 4.0, and the circular economy in courier chains, while Köhler *et al.* (2021) warn that the transition from blockchain to sustainable outcomes is not automatic, but dependent on implementation conditions and institutional articulation. These studies reinforce the argument that, in financial services, smart contracts can enhance efficiency and traceability, but require integrated ecosystems and appropriate organizational capabilities.

Trust in decentralized environments depends not only on code, but also on the quality of external data and validation architectures. Caldarelli *et al.* (2020) examine the oracle problem and show that the connection between real-world events and their digital representation is a critical point for the reliability of blockchain systems. Later, Caldarelli (2024) deepens this discussion by arguing that applications oriented toward sustainability and the circular economy require clear sectoral frameworks and realistic expectations regarding the transformative potential of the technology. From an organizational design perspective, Bruel and Godina (2023) develop a smart contract architecture for industrial symbiosis, while Abbas *et al.* (2026) show that willingness to share data in manufacturing markets depends on perceptions of control and trust. From a financial perspective, these contributions are essential because they show that the smart contract does not eliminate the need for trust, but redistributes it across data, validation, and governance infrastructures.

Blockchain-based digitalization has also been studied as a support for services, documentary processes, and transactional infrastructures. Lario *et al.* (2025) propose a blockchain business model that illustrates how services can be structured around programmable validations and automated relationships. In a technical dimension, Gumzej *et al.* (2026) analyze resilient digital infrastructures for highly transaction-intensive applications, a central issue for financial platforms. On the documentary side, Precht *et al.* (2026) review the foundations of blockchain-based document management systems, emphasizing their value for traceability, integrity, and paperless processes. In an applied contribution, Zabala-Vargas *et al.* (2024) show that even certified notifications can be optimized through this technology. Accordingly, the literature supports the argument that smart contracts form part of a broader digital services infrastructure in which interoperability, verifiable documentation, and operational resilience are indispensable conditions.

Security and data sovereignty likewise constitute a structural component of the digital transformation process. Sanober and Anwar (2025) develop a trust protocol combining reputation and consensus to strengthen the security of blockchain networks in sensitive applications. Similarly, Thantharate and Thantharate (2023) propose a permissioned Zero Trust architecture to improve privacy and interoperability. From an institutional perspective, Epasto (2025) introduces the notion of digital trust ecosystems

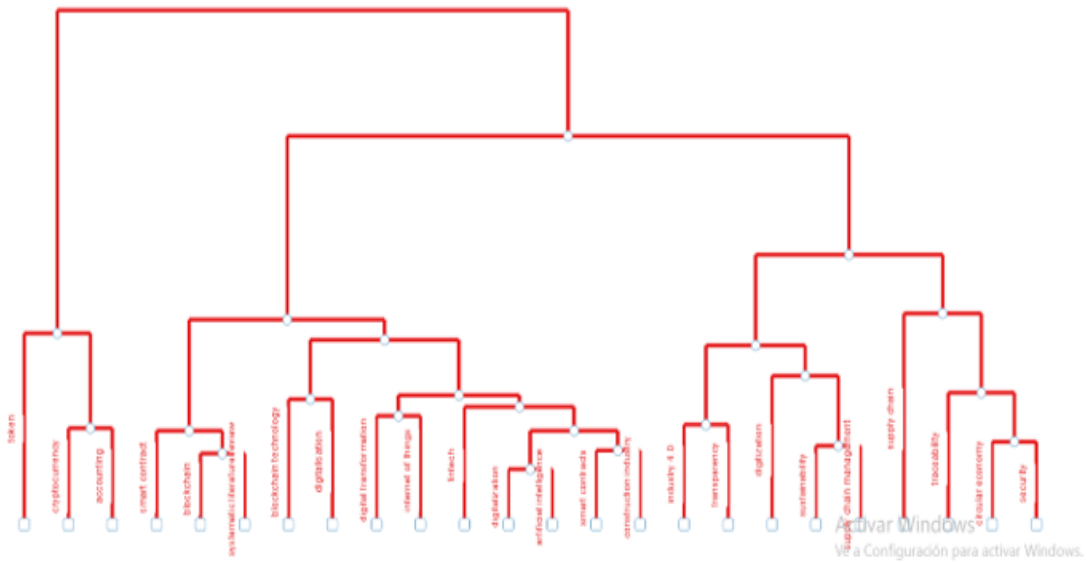



**Figure 9:** Factor Analysis and Thematic Clustering.

and shows that trust can be mapped as a relational and territorial quality. Finally, Merlec and in (2024) examine decentralized storage systems that favor data self-sovereignty. This theoretical body is directly applicable to financial services, since the deployment of smart contracts requires secure infrastructures, clear access rules, and reliable mechanisms for the safeguarding and circulation of information.

Another line within the corpus links blockchain with technological integration, sensors, environmental monitoring, and intelligent physical infrastructures, showing that smart contracts can operate as coordination layers within complex systems. Appasani *et al.* (2022) point out that blockchain-based smart grids face architectural, interoperability, and cybersecurity challenges. In the same logic, Zhang *et al.* (2020) present intelligent platforms for water management built on technological integration and blockchain. Enescu *et al.* (2020) demonstrate that the technology can even be integrated into irrigation systems supported by photovoltaic infrastructure, while Satilmisoglu *et al.* (2024) synthesize blockchain opportunities for water resource management. Although these studies are situated outside the financial core, they provide a relevant conceptual foundation: smart contracts acquire greater value when linked to verifiable external data and to systems capable of automating responses under predetermined conditions, something fully transferable to insurance, credit, or conditional payments.

The research also shows that blockchain is being incorporated into supervision systems, quality control, and decision-making in critical infrastructure environments. Zheng *et al.* (2025) highlight its application in food and agricultural critical infrastructures for security and traceability purposes. Thuy *et al.* (2025), in turn, show that water quality monitoring through blockchain and digital technologies requires overcoming both technical and governance barriers. In the contractual domain, Eze and Ameyaw (2025) identify concrete applications and benefits of smart contracts in public-private partnerships, while Toufighi *et al.* (2025) incorporate decision-support tools into blockchain-driven sustainable supply chains. These contributions strengthen the understanding of financial services as complex systems requiring continuous monitoring, coordination among multiple actors, and automation based on traceable rules.

Project-intensive sectors and contract compliance contexts offer another important source of evidence for understanding the potential of smart contracts. Ye *et al.* (2022) systematize the benefits and challenges of smart contracts in construction, highlighting their capacity to automate milestones, payments, and verifications. In the African context, Olusola and Phung (2025) propose an adoption framework tailored to the construction industry, while Gouda Mohamed *et al.* (2025) examine the factors conditioning their use in the MENA region. Complementarily, Ebekozien *et al.* (2024) demonstrate that the level of readiness among stakeholders remains uneven. This group of studies provides valuable theoretical input for the financial sector, since it reveals that the effectiveness of smart contracts depends not only on technical design, but also on digital maturity, institutional capacity, and the willingness of participants to operate under automated logics.

The blockchain-related digital transformation also extends to transport, engineering, and technical training, revealing the breadth of the phenomenon. Kouroupis and Sotiropoulos (2024) warn that the digital revolution in maritime transport increases cyber risks and requires new protection strategies. In relation to data management, Kumar and Jeyachandran (2025) show that blockchain can improve information management in maritime engineering. From the standpoint of training and technological transfer, Celik *et al.* (2024) analyze the use of blockchain in energy-efficiency training programs, while Shinde *et al.* (2021) link blockchain to the protection of artificial intelligence applications and open innovation processes. The relevance of these studies to the financial field lies in their confirmation that effective digitalization requires not only technology, but also human capabilities, cybersecurity frameworks, and robust information design.

The institutional and public governance dimension must also be incorporated into the analysis. Abdelsalam *et al.* (2025) argue that smart public procurement can benefit from blockchain by increasing transparency and traceability, although it requires substantial legal and institutional adjustments. From a critical perspective, Diaz Valdivia (2023) examines the tensions between decentralization and reintermediation, showing that blockchain platform governance does not always reproduce the original promise of distributed autonomy. This reflection is complemented by Chiarini and Compagnucci (2022), who address the legal and economic challenges of peer-to-peer trade and data protection in blockchain-based energy markets. Finally, Islam *et al.* (2023) question the economic sustainability of certain blockchain models, particularly mining. These contributions are important for the study of financial services because they remind us that digital transformation must also be examined through the lens of power tensions, costs, feasibility, and regulation.

Complementarily, the literature has begun to explore how blockchain affects knowledge management, competency certification, and the configuration of new digital spaces. Selvakumar *et al.* (2025) argue that the integration of blockchain with information governance can strengthen institutional transparency. In an early contribution, Novikov *et al.* (2018) proposed the use of distributed ledgers and smart contracts for competency certification, anticipating a logic of verifiable credentials that is now widely discussed. More recently, Abramov *et al.* (2024) explore the use of blockchain in immersive environments and participatory design, while Kraus and Kraus (2025) interpret the metaverse as part of the institutionalization of new digital economies. Although these studies do not focus

exclusively on financial services, they broaden the theoretical horizon of the study by showing that contractual automation can be integrated into increasingly complex digital ecosystems, where identity, ownership, and transaction tend to become natively digital.

From a prospective perspective, the literature suggests that smart contracts should be understood as a coordination technology within intelligent and interconnected ecosystems. Li *et al*. (2025) emphasize that contracts play a key role in value co-creation between IoT platforms and manufacturers of smart products, demonstrating that contractual automation not only controls transactions, but also organizes complex economic relationships. From a normative perspective, Howells (2020) reminds us that consumer protection must remain a guiding principle in the midst of the Fourth Industrial Revolution. At the methodological level, Taques (2025) confirms the usefulness of bibliometric analysis for mapping technological knowledge structures and revealing patterns of thematic convergence. Finally, Manta *et al*. (2026) broaden the horizon of the field by linking artificial intelligence and machine learning with sustainable banking, suggesting that the next stage of financial transformation will combine contractual automation, advanced analytics, and sustainability objectives.

In summary, the set of analyzed studies supports the argument that smart contracts constitute a strategic component of the digital transformation of financial services, as they provide mechanisms of automation, traceability, and programmable trust. However, the literature also shows that their consolidation depends on a complex convergence among technological innovation, regulation, security, interoperability, governance, and institutional acceptance. For this reason, the analysis of this field requires an integrative perspective that recognizes both the potential of blockchain and smart contracts to redesign financial services and the legal, organizational, and technical limitations that still condition their effective deployment.

## LIMITATIONS

This study has several limitations that should be acknowledged. First, the review was based exclusively on Scopus-indexed documents. Although Scopus offers broad multidisciplinary coverage and high-quality metadata for bibliometric analysis, this decision may have excluded relevant studies indexed in other academic databases, professional repositories, or specialized sources in law, finance, computer science, and technology. Therefore, the results should be interpreted as representative of the Scopus-indexed literature rather than of the entire body of knowledge on smart contracts and digital transformation in financial services.

Second, the inclusion criteria restricted the corpus to open-access publications written in English and classified as articles or review articles. While these criteria increased transparency, accessibility, and comparability within the dataset, they may also have reduced the linguistic, regional, and documentary diversity of the review. Relevant studies published in other languages, conference proceedings, books, book chapters, industry reports, or restricted-access journals may not have been included.

Third, the methodological design relied on bibliometric analysis, science mapping, and natural language processing. These techniques are useful for identifying publication trends, conceptual structures, thematic clusters, and semantic patterns; however, they do not replace an in-depth qualitative assessment of the legal, technological, organizational, and financial implications of each individual study. Consequently, the findings provide a structured overview of the field but do not measure the actual level of implementation or effectiveness of smart contracts in real banking, FinTech, or InsurTech environments.

Finally, the results are conditioned by the search strategy, keywords, metadata quality, and indexing practices of Scopus. Because smart contracts and digital transformation are evolving research areas, some emerging contributions may not yet be indexed or may use alternative terminology not captured by the search equation. Future reviews could expand the database coverage, include additional document types, and compare results across different academic and professional sources.

## PRACTICAL IMPLICATIONS

The findings of this study have practical implications for financial institutions, FinTech firms, and InsurTech companies. For banking institutions, smart contracts may support the automation of payment processes, collateral verification, loan servicing, compliance monitoring, and continuous auditing. These applications can reduce operational frictions, improve transaction traceability, and strengthen the reliability of financial records. However, their effective implementation requires robust data governance, cybersecurity safeguards, interoperability with legacy systems, and alignment with regulatory frameworks.

For FinTech firms, the results suggest that smart contracts can contribute to the development of more transparent, programmable, and user-centered financial services. Their use may support digital payments, decentralized finance applications, automated lending, tokenized assets, and programmable compliance mechanisms. In this context, smart contracts can help FinTech companies create scalable services based on automation, traceability, and digital trust, provided that adequate safeguards are established to manage risks related to data quality, legal enforceability, user protection, and technological vulnerability.

For InsurTech companies, smart contracts offer opportunities to improve policy administration, claims processing, parametric insurance, fraud reduction, and real-time verification of contractual conditions. By connecting contractual execution with reliable data sources, these technologies can accelerate

compensation processes and increase transparency between insurers and policyholders. Nevertheless, their adoption requires careful attention to oracle reliability, consumer protection, regulatory recognition, and the explainability of automated decisions.

Overall, the practical relevance of smart contracts in financial services depends not only on their technical capacity to automate transactions, but also on the institutional conditions that support their legitimate and trustworthy use. Financial organizations should therefore approach smart contracts as part of a broader digital transformation strategy that integrates technology, regulation, cybersecurity, organizational readiness, and user trust.

## CONCLUSION

This study provided a structured understanding of the evolution of knowledge on smart contracts and their relationship with digital transformation in financial services, particularly in FinTech, banking, and insurance. Based on a systematic review of 84 studies, complemented by bibliometric analysis, science mapping, and natural language processing, the findings confirm that this field constitutes a recent, active, and expanding line of inquiry, supported by an increasingly visible, collaborative, and interdisciplinary scientific base. The sustained growth of publication output, the diversity of keywords, and the breadth of publication sources indicate that the topic has moved beyond a marginal position to become a consolidated area of academic interest.

The findings also show that smart contracts should not be understood solely as technical tools associated with blockchain, but rather as mechanisms of verifiable automation capable of reconfiguring processes of intermediation, control, traceability, compliance, and governance in financial services. In this sense, the reviewed literature confirms that their contribution extends beyond operational efficiency, as it also affects risk management, legal certainty, continuous auditing, financial product innovation, and the creation of new architectures of digital trust. Thus, the digital transformation of the financial sector emerges as a multidimensional phenomenon in which distributed infrastructure, contractual automation, regulation, data security, and organizational innovation converge.

From a bibliometric perspective, the results suggest that the field has moved from a stage of rapid expansion toward one of scientific consolidation. The pattern of scientific production reveals a recent and sustained annual growth trajectory, progressive accumulation of publications, and signs of relative maturity, indicating that future contributions will likely focus less on quantitative expansion and more on thematic specialization, analytical depth, and concrete applications. This evolution suggests that research on smart contracts in financial services has already reached a sufficient critical mass to sustain more sophisticated discussions on adoption, impact, regulation, and scalability.

At the thematic level, the study shows that the intellectual core of the field remains structured around blockchain, smart contracts, and digital transformation, while progressively expanding toward domains such as sustainability, traceability, security, auditing, artificial intelligence, supply chains, and regulatory governance. This diversification confirms that the literature has evolved from a predominantly technological approach toward a more applied, interdisciplinary, and problem-oriented agenda. For the financial sector, this implies that the adoption of smart contracts cannot be analyzed in isolation, but rather in relation to broader ecosystems of data, regulation, interoperability, and institutional trust.

The review further suggests that the transformative potential of smart contracts in financial services depends on prior conditions that go beyond the technical design of the tool itself. The evidence indicates that factors such as data quality, institutional readiness, interoperability, cybersecurity, regulatory adequacy, and a clear distribution of responsibilities are decisive for effective adoption. Consequently, the expected benefits in terms of efficiency, friction reduction, payment automation, smart insurance, or programmable compliance can only be fully realized when organizational and regulatory frameworks are capable of supporting their operation in a legitimate and trustworthy manner.

From a methodological standpoint, the study also demonstrates the value of integrating systematic review, bibliometrics, science mapping, and natural language processing to analyze emerging and complex fields. This combination made it possible not only to describe the growth of the literature, but also to identify thematic cores, conceptual connections, research gaps, and future directions. Accordingly, one of the study's main contributions lies in offering a structured, reproducible, and analytically robust overview of the state of the art on smart contracts and digital transformation in financial services.

Finally, it is concluded that the field still presents important opportunities for further development. Future research should prioritize empirical studies on the implementation of smart contracts in real financial environments, particularly in banking operations, FinTech platforms, InsurTech business models, digital payments, automated lending, and programmable compliance systems. Comparative studies across financial subsectors are also needed to determine whether adoption barriers differ between banking, insurance, decentralized finance, asset management, auditing, and regulatory supervision. In addition, future studies should develop indicators to measure the organizational, legal, and operational impact of smart contracts, including cost reduction, processing time, auditability, user trust, regulatory effectiveness, cybersecurity resilience, and interoperability with existing financial infrastructures. Further research should

also examine the integration of smart contracts with artificial intelligence, digital identity systems, sustainable finance, and central bank digital currencies. In this way, future research will not only expand the theoretical knowledge base of the field, but also provide practical evidence to support strategic decision-making in the digital transformation of financial services.

## ABBREVIATIONS

**COVID-19:** Coronavirus Disease 2019; **FinTech:** Financial Technology; **InsurTech:** Insurance Technology; **RegTech:** Regulatory Technology; **SDG:** Sustainable Development Goal; **SDGs:** Sustainable Development Goals; **PRISMA:** Preferred Reporting Items for Systematic Reviews and Meta-Analyses; **NLP:** Natural Language Processing; **IoT:** Internet of Things; **CBDC:** Central Bank Digital Currency; **MENA:** Middle East and North Africa; **IEEE:** Institute of Electrical and Electronics Engineers; **ISPRS:** International Society for Photogrammetry and Remote Sensing; **R-Studio:** R Statistical Computing Environment (RStudio); **DAO:** Decentralized Autonomous Organization.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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