Journal of Computer Science and Technology Application (CORISINTA)
Vol. 3, No. 2, August 2026, pp. 117∼129
E-ISSN: 3064-3597 | P-ISSN: 3046-7616, DOI: 10.33050

Smart Contract Based Data Strategy for Startup Growth in Digital Business Systems

Paroli[1], Muhtarom[2], Mungkap Mangapul Siahaan[3], Derlina[4], Kgomotso Moyo[5*]
[1]Faculty of Economics and Business, University Sebelas April, Indonesia
[2]Faculty of Law, Social and Political Sciences, Universitas Terbuka, Indonesia
[3]Faculty of Teacher Training and Education, Universitas HKBP Nommensen Pematangsiantar, Indonesia
[4]Faculty of Mathematics and Natural Science, State University of Medan, Indonesia
[5]Department of Computer Science, Mfinitee Incorporation, South Africa
[1]paroli.feb@unsap.ac.id, [2]muhtarom@ecampus.ut.ac.id, [3]mungkapsiahaan@gmail.com, [4]derlina@unimed.ac.id,
[5]kgomotsoo.m@mfinitee.co.za
***Corresponding Author**

Article Info

Article history:

Submission, February 10, 2026
Revised, February 26, 2026
Accepted, March 30, 2026
Published, June 29, 2026

Keywords:

Smart Contracts
Cybersecurity
Digital Business Systems
Startup Growth
Data Strategy

ABSTRACT

This study explores how smart contract based data strategies can support startup growth in digital business systems characterized by competition, limited resources, and increasing demand for transparency. In the context of rapid digital transformation, startups require reliable data governance mechanisms to manage transactions, automate business processes, and strengthen stakeholder trust. **The background** of this research highlights that conventional data management often faces challenges related to data integrity, operational inefficiency, centralized control, and limited transparency, making smart contracts a strategic alternative for supporting secure and automated digital business operations. **The objective** of this study is to analyze how smart contract based data strategies contribute to startup growth by enhancing data transparency, workflow automation, trust formation, and operational scalability. Employing a qualitative conceptual approach, this study synthesizes academic literature, blockchain related studies, and documented insights on smart contract implementation in digital business environments. The analysis focuses on key dimensions, including decentralized data management, automated transaction execution, transparency mechanisms, security assurance, and workflow efficiency. **The results** indicate that smart contracts function not merely as blockchain tools but as strategic data mechanisms that enable startups to reduce operational risks, improve process reliability, and strengthen digital business credibility. **The conclusion** reveals that effective smart contract implementation can support sustainable startup growth by improving data accountability, enhancing stakeholder confidence, and enabling scalable digital operations. This study contributes to blockchain and digital business literature by positioning smart contracts as strategic data capabilities for startup development.

DOI: https://doi.org/10.33050/corisinta.v3i2.174

1. INTRODUCTION

Smart contracts play an important role in determining how digital business systems manage data, execute agreements, and ensure transactional reliability without excessive dependence on centralized interme-

diaries. This condition positions smart contracts as critical components of blockchain based business ecosystems, especially for startups seeking to improve transparency, accountability, and scalability. By embedding business rules into self executing digital agreements, startups can automate transaction validation, reduce manual intervention, and strengthen confidence among customers, partners, and investors [1]. Recent developments in blockchain and decentralized applications further strengthen the relevance of smart contract based data strategies, as digital businesses increasingly require secure, traceable, and tamper resistant data management systems. Beyond technical implementation, smart contracts operate within complex digital infrastructures involving distributed ledgers, automated workflow execution, data verification mechanisms, and decentralized trust formation processes [2].

From a computing perspective, smart contract based data strategies function as programmable governance mechanisms that interact with decentralized digital environments. Blockchain systems continuously record transactional data through distributed validation processes, cryptographic verification, consensus mechanisms, and immutable ledger structures [3, 4]. Within these architectures, business agreements, workflow conditions, transaction rules, and data access permissions are transformed into machine executable logic that supports automated decision making. This perspective expands the interpretation of smart contracts from purely technical blockchain scripts into strategic data governance layers embedded within digital business systems. Consequently, smart contract implementation becomes increasingly connected with data integrity, workflow automation, cybersecurity assurance, operational transparency, and algorithm aware business process management [5].

Despite the growing recognition of smart contracts in blockchain based systems, academic discussions frequently position smart contracts primarily as technical instruments for transaction execution, thereby underestimating their broader strategic implications for startup growth. In practice, smart contract based data strategies intersect with business capability development through decentralized data management, automated workflow coordination, trust formation, and scalable digital operations [6]. Startups require reliable mechanisms to manage complex data flows, reduce operational inefficiencies, and build stakeholder confidence in competitive digital markets. Addressing this gap, this study develops a conceptual framework that integrates blockchain capability perspectives, decentralized data strategy, smart contract functionality, and measurable digital business performance constructs to explain startup growth mechanisms. The framework introduces analytical dimensions supported by data transparency, automation efficiency, security assurance, workflow reliability, and scalability indicators, while also proposing conceptual relationships that enable future empirical validation across blockchain applications, digital business systems, and decentralized information management research contexts [7, 8].

2. LITERATURE REVIEW

2.1. Smart Contract Based Data Strategy in Digital Business

Smart contract based data strategy is widely conceptualized as an approach that utilizes self executing digital agreements to manage, verify, and automate data transactions within blockchain based business systems. In digital business literature, smart contracts are recognized as programmable mechanisms that integrate decentralized data management, transaction automation, transparency, security, and workflow efficiency. Rather than functioning as isolated technical tools, these elements interact to support reliable data exchange, reduce dependency on centralized intermediaries, and strengthen trust among business stakeholders [9].

Recent studies emphasize that smart contracts reflect an alignment between digital business processes and decentralized trust mechanisms. Business transactions, service agreements, payment conditions, and data access rules can be encoded into smart contracts, allowing them to be executed automatically when predefined conditions are fulfilled. In digital business environments, this capability improves operational efficiency, data integrity, and accountability [10]. For startups, smart contract based data strategies serve as a mechanism to reduce information asymmetry, minimize operational risk, and enhance stakeholder confidence without requiring complex centralized governance structures. Therefore, smart contracts can support startup growth by enabling transparent data management, automated workflow execution, and scalable digital business operations [11].

2.2. Startup Growth in Blockchain Based Digital Markets

Startup growth is commonly associated with customer acquisition, market expansion, operational scalability, transaction efficiency, and revenue sustainability. Digital markets provide startups with opportunities to enter business ecosystems more rapidly; however, they also create challenges related to trust, data security,

transaction transparency, and workflow complexity. As a result, startup growth is not solely determined by product innovation or digital promotion, but also by the ability to manage data reliably, automate business processes, and build stakeholder confidence in decentralized digital environments [12, 13].

Literature on digital entrepreneurship highlights that trustworthy and efficient digital infrastructure plays a critical role during the early stages of startup development. Smart contract based data strategies contribute to legitimacy building by enabling transparent transactions, automated agreement execution, and immutable data records within blockchain based systems. Unlike conventional centralized systems that may create dependency on intermediaries, smart contracts support direct, traceable, and rule based interactions among users, partners, and service providers. Over time, consistent implementation of smart contracts can strengthen operational credibility, reduce transaction risk, improve workflow efficiency, and support scalable business growth. Therefore, in blockchain based digital markets, smart contracts serve as strategic mechanisms that help startups develop trust, reliability, and sustainable competitive advantage [14].

2.3. Smart Contracts in the Context of Artificial Intelligence, Big Data, and Cyber Infrastructure

Recent developments in digital ecosystems indicate that smart contract based data strategies are increasingly shaped by the integration of Artificial Intelligence, Big Data analytics, cybersecurity frameworks, and decentralized digital infrastructures. Smart contracts operate as programmable agreements that automatically execute predefined rules within blockchain based systems, enabling transparent, traceable, and tamper resistant data transactions. In modern digital business systems, these capabilities are closely connected to large scale data processing, automated decision making, and secure transaction validation. Artificial Intelligence can support smart contract ecosystems by improving anomaly detection, predictive analytics, fraud monitoring, and automated workflow optimization. Meanwhile, Big Data analytics allows startups to extract meaningful insights from transaction records, user behavior, operational logs, and decentralized data flows, enabling more adaptive and evidence based business decisions [15]. For startups, these analytical capabilities support faster identification of market opportunities, better resource allocation, and more reliable digital service delivery. In parallel, cybersecurity factors such as cryptographic validation, secure protocols, identity verification, and data integrity mechanisms play an important role in maintaining trust, protecting digital assets, and reducing operational risks within blockchain enabled business environments [16].

From an information systems perspective, smart contract based digital environments operate through multilayer computational architectures consisting of distributed ledgers, consensus mechanisms, cryptographic verification, data oracles, decentralized applications, and automated execution layers. Within these architectures, smart contract based data strategies function as programmable governance mechanisms that interact with algorithmic and decentralized validation processes. Contemporary blockchain systems integrate multiple technical signals, including transaction validity, ledger immutability, access control, execution accuracy, data provenance, network reliability, and security compliance [17, 18]. These signals are processed through distributed infrastructures that evaluate and record transactions without depending on a single centralized authority. Consequently, smart contract implementation must be understood as the systematic alignment of business rules, data governance structures, cybersecurity mechanisms, and workflow automation with blockchain based execution logic. This computational interpretation reinforces the positioning of smart contracts as data driven technical capabilities embedded within secure, transparent, and scalable digital business infrastructures.

2.4. Smart Contracts as a Strategic Capability

From a strategic management perspective, smart contracts can be understood as an intangible digital capability that supports data governance, transaction automation, and trust formation in blockchain based business systems [19]. Drawing on the resource based view, smart contracts enable startups to leverage programmable business rules, decentralized data structures, transparent transaction records, and automated workflow mechanisms to achieve competitive advantage. Unlike conventional financial or physical resources, these blockchain based capabilities are embedded in digital infrastructure and organizational knowledge, making them difficult for competitors to imitate directly [20].

Recent research increasingly positions smart contracts as a long term strategic investment rather than merely a technical blockchain feature. Smart contract capabilities influence strategic choices related to data management, transaction reliability, operational efficiency, and stakeholder coordination. For startups, this strategic orientation allows smart contracts to function as growth enablers that support trust building, cost reduction, process automation, and scalable digital operations [21, 22]. By integrating smart contracts into core business processes, startups can strengthen their digital credibility, reduce dependency on intermediaries, and

create more transparent value exchange within digital business ecosystems. Therefore, smart contracts can be positioned as strategic capabilities that contribute to sustainable startup growth and long term competitiveness [23].

Table 1. Summary of Previous Studies on Smart Contracts and Startup Growth

Research Focus	Methodological Approach	Key Findings	Research Limitations
Smart contracts and decentralized digital systems	Conceptual and technical analysis	Smart contracts enable automated transactions, decentralized execution, and reduced reliance on intermediaries	Limited emphasis on startup growth and digital business scalability
Blockchain applications in business and data management	Systematic literature review	Blockchain improves transparency, traceability, and trust in digital transactions	The study focuses broadly on blockchain applications rather than startup specific data strategies
Blockchain technology and smart contract mechanisms	Technical review	Smart contracts support programmable trust, data immutability, and automated business logic	Empirical validation in startup environments remains limited
Blockchain based contracts and business efficiency	Economic and analytical review	Smart contracts can reduce transaction costs and improve coordination among digital stakeholders	Growth mechanisms in early stage startups are not explicitly examined

Table 1 summarizes key previous studies examining the role of smart contracts and blockchain based data strategies within digital business and startup growth contexts by categorizing each study according to research focus, methodological approach, key findings, and identified limitations. Overall, the reviewed literature consistently highlights smart contracts as important mechanisms for improving transaction automation, data transparency, workflow efficiency, and trust formation across decentralized digital environments. However, the synthesis also indicates that many studies position smart contracts primarily within technical blockchain discussions, frequently emphasizing system architecture, transaction execution, or general blockchain applications rather than their strategic role in supporting early stage business development [24].

The table further reveals a significant research gap related to the specific growth dynamics of startups, including resource limitations, early stage legitimacy challenges, data governance issues, transaction reliability, and scalability constraints that are not sufficiently addressed in prior research [25]. In addition, several studies rely heavily on conceptual, technical, or broad blockchain based approaches, which limits their direct applicability across diverse startup contexts. Therefore, Table 1 demonstrates that although the technical value of smart contracts is widely recognized, their role as a dedicated data strategy for startup growth remains underexplored. This gap provides a strong justification for the present study, which adopts a qualitative and growth oriented perspective to reposition smart contracts as strategic data capabilities that support transparency, automation, trust, and scalable development in digital business systems [26].

2.5. Research Gap and Alignment with Sustainable Development Goals SDGs

Despite the growing body of literature on smart contracts within blockchain technology, decentralized systems, and digital business management, a clear research gap remains in understanding smart contract based data strategy as a long term growth mechanism for startups. Prior studies largely emphasize technical outcomes such as automated transaction execution, ledger immutability, security enhancement, and decentralized validation, while overlooking the unique conditions faced by startups, including resource constraints, early stage legitimacy building, limited governance capacity, and scalability challenges. As a result, the cumulative and process oriented role of smart contracts in shaping data transparency, workflow automation, trust formation, transaction reliability, and operational scalability is insufficiently explored. This limitation restricts the conceptualization of smart contracts as an integrated strategic capability that supports startup growth over time [27].

In addition, the relationship between smart contract based startup growth and the SDGs has received limited academic attention. Smart contract based data strategy aligns with SDG 8 Decent Work and Economic Growth by supporting inclusive entrepreneurial development, reducing transaction inefficiencies, and enabling startups to build more reliable digital business operations. It also supports SDG 9 Industry Innovation and Infrastructure through the strengthening of blockchain based infrastructure, decentralized data governance, and innovation driven business models [28, 29]. Furthermore, it contributes to SDG 12 Responsible Consumption and Production by promoting transparent, traceable, and accountable digital transactions that reduce information asymmetry and improve responsible business practices. By addressing both the strategic gap and sustainability dimension, this study positions smart contracts as responsible data mechanisms that enable startups to achieve secure, transparent, and scalable growth within digital business systems [30].

3. METHODOLOGY

3.1. Research Design

The analysis adopts a qualitative research design with a conceptual analytical orientation to examine the role of smart contract based data strategies in supporting startup growth within digital business systems. Rather than testing hypotheses through statistical models, this research aims to build an integrative understanding of how smart contracts function as strategic data mechanisms that enable transparency, automation, trust formation, and operational scalability [31]. A qualitative design is appropriate because the effectiveness of smart contracts is closely related to contextual factors such as decentralized data governance, transaction reliability, workflow complexity, stakeholder trust, and blockchain infrastructure readiness, which cannot be fully captured through purely quantitative indicators [32].

By synthesizing theoretical perspectives and documented empirical insights, this study positions smart contracts as strategic capabilities that shape long term digital competitiveness. While this study adopts a conceptual analytical approach, the proposed framework is designed to support future empirical validation. The measurable constructs and technical indicators identified in this study provide a foundation for quantitative modeling, case based investigation, or mixed method research involving real world startup datasets, blockchain transaction records, and digital workflow performance indicators. This design allows the conceptual structure to be operationalized in subsequent empirical studies [33].

To improve methodological rigor and align the study with blockchain, information systems, and computational analytics research standards, the conceptual framework is also interpreted through a computational modeling perspective. Each smart contract strategic dimension is treated as a latent capability construct that can be operationalized using observable digital performance indicators derived from blockchain based systems and digital business environments. These indicators may include transaction automation accuracy, data transparency, smart contract execution reliability, security assurance, workflow efficiency, and scalability performance [34].

While the literature synthesis provides conceptual grounding, the methodological approach of this study emphasizes analytical transformation. Specifically, theoretical constructs derived from prior literature are systematically translated into measurable digital performance indicators and blockchain based interaction variables [35]. This transformation enables the framework to function not only as a conceptual interpretation but also as an analytically structured model that supports future empirical and computational validation [36].

Furthermore, the proposed structure supports construct based modeling approaches commonly applied in blockchain and digital analytics research, including structural equation modeling, predictive analytics modeling, smart contract performance evaluation, and decentralized workflow analysis. To improve methodological transparency, the analytical procedure follows a structured conceptual workflow consisting of four stages: literature driven construct identification, thematic synthesis of smart contract based data strategy dimensions, mapping of constructs into measurable blockchain and digital business performance indicators, and computational interpretation using decentralized data governance, workflow automation, and blockchain execution logic. This staged workflow clarifies how conceptual insights are systematically translated into analytical and technically interpretable constructs [37].

3.2. Data Source

The data for this conceptual synthesis were derived from multiple secondary sources, including peer reviewed academic journals, conference proceedings, blockchain related books, industry reports, and documented studies on smart contract implementation in digital business systems. To ensure conceptual relevance

and timeliness, priority was given to publications released within the last five years, particularly those addressing blockchain technology, smart contracts, distributed ledger systems, decentralized data governance, digital business transformation, and startup growth dynamics. Authoritative practitioner sources were also included to capture real world smart contract practices that complement academic perspectives [38, 39]. The triangulation of academic and industry oriented sources enhances the analytical depth and practical validity of the study.

In addition to academic and industry literature, the analytical interpretation also incorporates conceptual insights from blockchain-based systems, decentralized applications, smart contract platforms, cybersecurity frameworks, and digital workflow management environments. Priority was given to recent high-impact publications from 2022 to 2026 to ensure the study aligns with current developments in smart contract automation, blockchain-based data management, and decentralized business infrastructures. The conceptual synthesis integrates digital performance indicators commonly associated with smart contract-based systems, including transaction efficiency, automation reliability, and system security metrics. Furthermore, cross-industry case studies and empirical findings were considered to contextualize theoretical constructs and provide practical relevance, enhancing the operationalization of the framework and supporting the identification of key dimensions for evaluating smart contract implementation in digital business ecosystems [40, 41].

Smart contract effectiveness may be operationalized using indicators such as transaction execution accuracy, automation reliability, validation latency, and transaction processing efficiency. Data transparency constructs may be measured through auditability, data traceability, ledger immutability, and accessibility of transaction records. Security assurance may be evaluated using cryptographic validation, access control mechanisms, vulnerability prevention, and data integrity protection. Workflow efficiency constructs may be derived from process automation level, reduction of manual intervention, error minimization, and operational completion time. Meanwhile, startup growth constructs may be assessed through scalability readiness, stakeholder trust, operational reliability, and digital service expansion potential [42]. This construct to indicator mapping strengthens the methodological transparency of the framework and enables future empirical validation using real world blockchain datasets, smart contract transaction logs, and digital business performance records [43].

3.3. Analytical Approach

The analysis follows a thematic synthesis approach in which recurring patterns and relationships within the literature were systematically identified, particularly focusing on the intersection of smart contracts, decentralized data strategy, blockchain-based workflow, and startup growth. Through careful examination, key dimensions of smart contract-based data strategy were extracted and organized into four primary themes: decentralized data management, automated transaction execution, security and trust assurance, and workflow efficiency. Each theme was further analyzed to understand its operational mechanisms, potential benefits, and practical implementation challenges in real-world startup environments. These themes were interpreted in relation to startup growth indicators such as operational scalability, stakeholder confidence, transaction reliability, digital service expansion, and sustainable business performance, highlighting the ways in which blockchain and smart contract technologies can drive organizational efficiency and trust [44]. In addition, the synthesis captured insights on cross-industry applications, regulatory considerations, and emerging best practices, providing a comprehensive view of how decentralized digital infrastructures can influence strategic decision-making. The findings also underscore the interdependencies between secure data governance, process automation, and innovation capacity, demonstrating that the adoption of smart contract-based systems is not merely technical but also strategic in facilitating long-term startup growth and competitive advantage.

The analytical process emphasizes relational logic, where interactions among smart contract dimensions produce indirect and cumulative growth effects rather than immediate financial outcomes. Decentralized data management improves transparency and reduces dependency on centralized intermediaries. Automated transaction execution enhances operational speed and reduces manual errors. Security and trust assurance strengthen stakeholder confidence through cryptographic validation and immutable records. Workflow efficiency supports scalability by simplifying repetitive business processes and improving coordination among digital actors [45]. This approach enables the study to present a holistic framework explaining how coordinated smart contract based data strategies support sustainable startup growth over time. Rather than treating smart contracts as isolated technical tools, the analysis positions them as strategic data mechanisms embedded within blockchain enabled digital business systems. This interpretation strengthens the alignment of the study with blockchain applications, smart contracts, distributed ledger technologies, and data workflow management [46, 47].

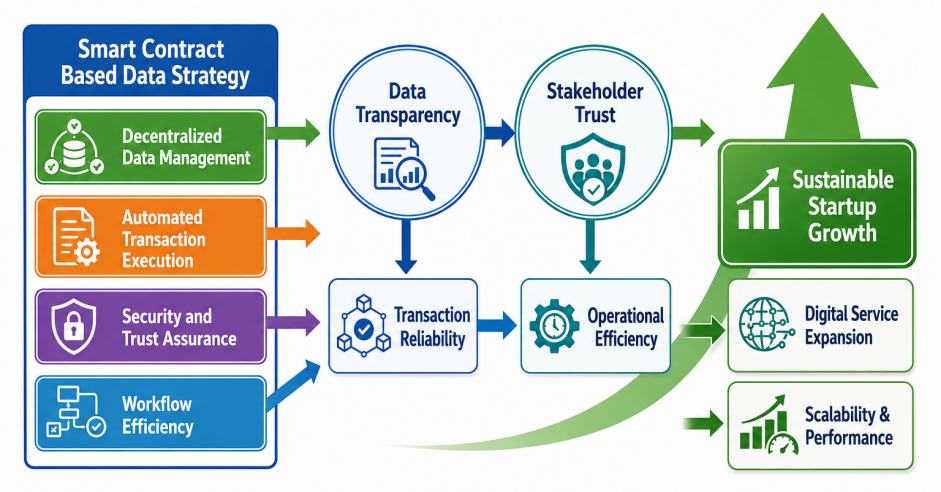

Figure 1. Conceptual Framework of Smart Contract Based Data Strategy Supporting Startup Growth

Figure 1 illustrates the relationship between smart contract based data strategy dimensions and startup growth outcomes in digital business systems. The main input dimensions include decentralized data management, automated transaction execution, security and trust assurance, and workflow efficiency. These dimensions influence intermediate outcomes such as data transparency, stakeholder trust, transaction reliability, and operational efficiency, which subsequently support sustainable startup growth [48]. The figure highlights that smart contracts contribute indirectly to growth by first strengthening data accountability, improving transactional reliability, and enhancing stakeholder confidence before driving digital service expansion, scalability, and business performance. In addition, the analytical synthesis generates operational construct indicators and a comparative strategic framework, enhancing the conceptual model's applicability for future quantitative, qualitative, or mixed method validation. Each smart contract based data strategy dimension can also be interpreted through technical performance indicators derived from blockchain transaction records, decentralized workflow systems, and digital business monitoring platforms, reinforcing the data driven nature of the proposed model.

3.4. Smart Contract Indicators and Blockchain Based Analytical Perspective

Although this study adopts a conceptual qualitative approach, a computational perspective is incorporated to strengthen the technical relevance of the proposed framework. Smart contract based data strategies can be interpreted as part of a blockchain based analytical pipeline involving data recording, validation, automated execution, monitoring, and feedback evaluation. In this structure, transaction data, agreement conditions, user interactions, and workflow records are processed through distributed ledger mechanisms, consensus validation, and cryptographic verification to ensure transparency, integrity, and trust in digital business systems.

Several measurable indicators are conceptually mapped to the main dimensions of smart contract based data strategy. Decentralized data management can be assessed through data traceability, ledger immutability, auditability, and accessibility of transaction records. Automated transaction execution may be evaluated through execution accuracy, transaction success rate, validation latency, and reduction of manual intervention. Security and trust assurance can be measured using cryptographic validation, access control reliability, vulnerability prevention, and data integrity protection. Meanwhile, workflow efficiency may be assessed through process completion time, error reduction, operational scalability, and coordination effectiveness among digital actors [49].

4. RESULTS AND DISCUSSION

The qualitative synthesis reveals that smart contract based data strategy plays a strategic role in supporting startup growth within digital business systems by strengthening transparency, transaction reliability, security, and workflow efficiency. From a technical perspective, smart contract performance can be evaluated through indicators such as transaction execution accuracy, validation latency, ledger transparency, data traceability, security reliability, and automation efficiency. These indicators show that smart contract driven growth can be supported by observable data from blockchain transaction logs, decentralized workflow records, and

system monitoring. Rather than functioning only as a technical blockchain feature, smart contracts operate as integrated data capabilities that help startups reduce dependency on intermediaries, minimize manual processes, improve stakeholder trust, and support operational scalability. Therefore, smart contract based data strategy can be positioned as a strategic mechanism for enhancing transparency, reliability, and sustainable startup growth in digital business systems.

4.1. Technical Evaluation Layer of Smart Contract Capability

Beyond strategic interpretation, the findings indicate that smart contract based growth mechanisms can be systematically evaluated through multidimensional technical diagnostics involving decentralized data management, automated transaction execution, security assurance, and workflow efficiency. Smart contract capability maturity may be assessed using indicators such as transaction execution accuracy, validation latency, ledger immutability, data traceability, cryptographic verification, access control reliability, workflow completion time, and operational scalability. From a data processing perspective, blockchain based systems record transaction data, validate agreement conditions through consensus mechanisms, execute predefined rules automatically, and generate transparent records that strengthen trust and accountability. This iterative process demonstrates that smart contracts operate not merely as technical blockchain scripts but as adaptive automation layers that connect business rules with decentralized execution mechanisms. Among the identified dimensions, decentralized data management strengthens transparency and auditability, automated transaction execution reduces manual intervention and operational errors, security assurance improves stakeholder confidence through tamper resistant records, and workflow efficiency supports scalable startup operations [50, 51]. By examining these measurable indicators as interaction based evaluation signals, the analytical synthesis positions smart contract capability as a dynamic and performance oriented system that supports transaction reliability, operational efficiency, stakeholder trust, and sustainable startup growth in digital business systems.

Table 2. Dimensions and Their Contribution to Start Up Growth

Dimension	**Strategic Function**	**Analytical Performance Role**	**Growth Contribution**	**Scalability & Digital Performance Implication**
Keyword Strategy	Aligns digital content with user search intent	Improves query relevance and search visibility signals	Targeted traffic acquisition	Enables scalable niche visibility through intent driven traffic expansion
Content Optimization	Enhances informational relevance and topical authority	Strengthens engagement and semantic relevance metrics	Brand credibility development	Supports scalable content driven authority and organic traffic accumulation
Technical	Ensures system accessibility and performance stability	Improves crawlability, indexing efficiency, and page experience signals	User retention and ranking stability	Improves platform scalability through infrastructure efficiency and performance stability
User Experience	Facilitates interaction quality and usability flow	Strengthens behavioral engagement and conversion indicators	Conversion potential and customer engagement	Enhances scalable engagement through interaction optimization and usability consistency

Table 2 maps smart contract based data strategy dimensions to their strategic functions, analytical roles, and contributions to startup growth. The findings show that decentralized data management improves transparency, automated transaction execution strengthens process reliability, security and trust assurance builds stakeholder confidence, and workflow efficiency supports scalability. Together, these dimensions

position smart contracts as an integrated data capability that enhances transaction reliability, operational efficiency, digital trust, and sustainable startup growth in digital business systems.

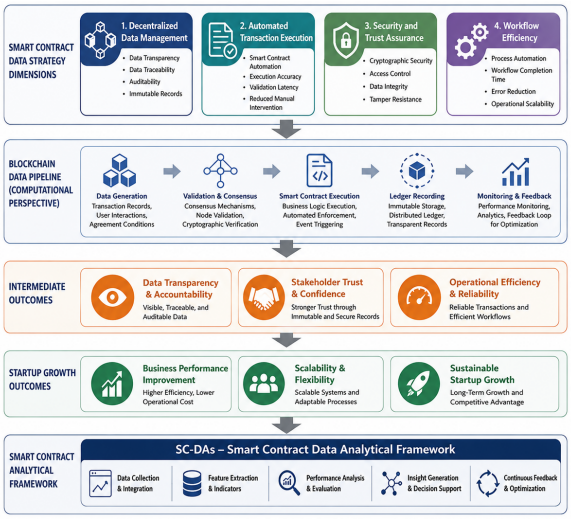

Figure 2. Strategic Mechanism for Supporting Startup Growth

Figure 2 illustrates how smart contract based data strategy supports startup growth in blockchain enabled digital business systems. The framework shows that decentralized data management, automated transaction execution, security and trust assurance, and workflow efficiency generate key indicators such as transaction accuracy, ledger transparency, data traceability, cryptographic verification, and workflow completion time. These indicators are processed through distributed ledger mechanisms, consensus validation, smart contract execution, and monitoring feedback loops. The process strengthens data transparency, stakeholder trust, transaction reliability, and operational efficiency, which ultimately support startup growth through improved performance, digital service expansion, scalability, and sustainable competitive advantage.

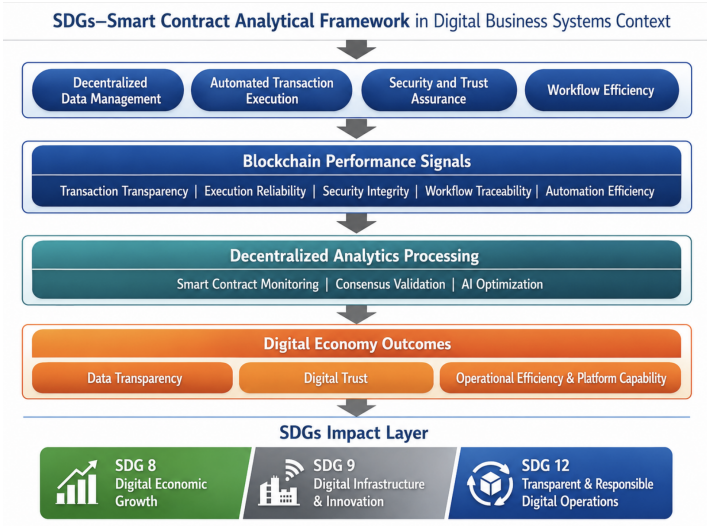

Figure 3. SDGs Analytical Framework in Digital Economy Context

Figure 3 extends the analytical framework by mapping smart contract based performance indicators to digital economy outcomes and selected SDGs. The figure shows how blockchain performance signals, including transaction transparency, execution reliability, security integrity, workflow traceability, and automation efficiency, are processed through decentralized analytics, smart contract monitoring, consensus validation, and AI optimization. These processes contribute to data transparency, digital trust, operational efficiency, and plat-

form capability. The framework is conceptually linked to SDG 8, SDG 9, and SDG 12 by supporting digital economic growth, innovation infrastructure, and transparent responsible digital operations.

5. MANAGERIAL IMPLICATIONS

The findings provide important managerial implications for startup founders, digital business managers, and technology decision makers in adopting smart contract based data strategies as part of core business operations. Smart contracts should not be treated merely as technical blockchain tools, but as strategic mechanisms for improving data governance, transaction reliability, cybersecurity assurance, and workflow automation. By implementing decentralized data management, automated transaction execution, security and trust assurance, and workflow efficiency, startups can reduce manual intervention, minimize operational errors, strengthen stakeholder confidence, and improve transparency in digital transactions. This is particularly important for early stage startups that often face limited resources, weak institutional trust, and high operational uncertainty.

From a practical perspective, managers should develop a clear implementation roadmap that includes smart contract auditing, access control policies, transaction monitoring, cryptographic validation, and integration with digital business analytics. Performance indicators such as transaction execution accuracy, validation latency, data traceability, security reliability, and workflow completion time can be used to evaluate the effectiveness of smart contract adoption. By continuously monitoring these indicators, startups can improve operational efficiency, reduce dependency on intermediaries, enhance digital trust, and support scalable business growth. Therefore, smart contract based data strategy can help managers build more secure, transparent, and sustainable digital business systems.

6. CONCLUSION

The results highlight that smart contract based data strategy functions as a strategic growth capability for startups operating in blockchain enabled digital business systems. By integrating decentralized data management, automated transaction execution, security and trust assurance, and workflow efficiency, smart contracts enable startups to strengthen transaction reliability, data transparency, and stakeholder confidence despite limited resources. The analysis suggests that smart contracts contribute to startup development through progressive mechanisms, including improved data accountability, operational automation, trust formation, and scalable digital service delivery. These intermediate outcomes are particularly important for early stage startups, where credibility, process reliability, and efficient resource utilization strongly influence adoption and business sustainability.

From a computational perspective, the proposed framework advances smart contracts beyond technical blockchain execution by positioning them within decentralized data governance and digital workflow management systems. Blockchain performance signals such as transaction transparency, execution reliability, security integrity, workflow traceability, and automation efficiency can be used to operationalize smart contract capability as a measurable digital business mechanism. By linking smart contract dimensions with distributed ledger mechanisms, consensus validation, cryptographic verification, and monitoring feedback loops, this study provides an analytical structure that connects blockchain technology with startup growth performance.

From a theoretical and practical standpoint, this study reconceptualizes smart contracts as strategic data capabilities embedded in digital business systems rather than standalone technical tools. Startups are encouraged to integrate smart contracts into core business processes to improve transparency, reduce operational inefficiency, minimize dependency on intermediaries, and support sustainable scalability. The framework also strengthens the relevance of smart contracts to blockchain applications, decentralized data management, workflow automation, and SDG oriented digital economy development. Future research can empirically validate this framework using blockchain transaction logs, smart contract performance metrics, longitudinal startup datasets, or case based studies to examine causal relationships between smart contract capability and sustainable startup growth outcomes.

7. DECLARATIONS

7.1. About Authors

Paroli (PP) https://orcid.org/0009-0001-1458-847X
Muhtarom (MM) https://orcid.org/0009-0002-1497-9574
Mungkap Mangapul Siahaan (MS) https://orcid.org/0000-0002-8785-1160
Derlina (DD) https://orcid.org/0000-0002-8650-129X
Kgomotso Moyo (KM) https://orcid.org/0009-0005-5779-562X

7.2. Author Contributions

Conceptualization: PP; Methodology: MM; Software: MS; Validation: DD and KM; Formal Analysis: PP and MM; Investigation: MS; Resources: DD; Data Curation: KM; Writing Original Draft Preparation: PP and MM; Writing Review and Editing: MS and DD; Visualization: KM; All authors, PP, MM, MS, DD and KM have read and agreed to the published version of the manuscript.

7.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7.4. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

7.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

REFERENCES

[1] J. R. Saura, D. Ribeiro-Soriano, and D. Palacios-Marqués, "From user-generated data to data-driven innovation: A research agenda for digital marketing analytics," *Journal of Business Research*, vol. 141, pp. 1–11, 2022.
[2] S. Kraus, M. Breier, and P. Jones, "Digital transformation and entrepreneurship: Current developments and future directions," *Journal of Business Research*, vol. 139, 2022.
[3] P. C. Verhoef *et al.*, "Digital transformation and customer analytics," *Journal of Marketing*, vol. 87, no. 4, 2023.
[4] H. Safitri, M. H. R. Chakim, and A. Adiwijaya, "Strategy based technology-based startups to drive digital business growth," *Startupreneur Business Digital (SABDA Journal)*, vol. 2, no. 2, pp. 207–220, 2023.
[5] M.-H. Huang and R. T. Rust, "Artificial intelligence in marketing: Progress and future directions," *Journal of Marketing*, vol. 87, no. 5, 2023.
[6] R. Berman, Z. Katona, and W. Rand, "Search engine optimization: Strategic and technical perspectives," *Marketing Science*, vol. 41, no. 6, 2022.
[7] Y. Zhang, K. Zhao, and H. Xu, "Web performance and user behavior signals in search ranking environments," *Information Systems Research*, vol. 35, no. 1, 2024.
[8] A. Kanivia, H. Hilda, A. Adiwijaya, M. F. Fazri, S. Maulana, and M. Hardini, "The impact of information technology support on the use of e-learning systems at university," *International Journal of Cyber and IT Service Management*, vol. 4, no. 2, pp. 122–132, 2024.
[9] M. Chen, X. Wang, and N. Koudas, "Generative engine optimization: How to dominate ai search," 2025, empirical SEO and AI search paradigm analysis.
[10] Chen, Wang, and N. Koudas, "Navigating the shift: A comparative analysis of web search and generative ai response generation," 2026, quantitative comparison between traditional SEO and AEO/GEO.
[11] S. Kim, W. Jeong, S. Kim, S. Lee, and D. Lee, "Sageo arena: A realistic environment for evaluating search-augmented generative engine optimization," 2026, benchmark for optimization strategies on generative search pipelines.
[12] P. Brüggemann, L. F. Martinez, and F. J. Martínez-López, "The future of analytics in digital marketing and electronic commerce," *Journal of Marketing Analytics*, vol. 13, pp. 571–573, 2025.

[13] E. R. Rahayu, A. Aprillia, R. Z. Ikhsan, A. Adiwijaya, and A. Kumara, "Cybersecurity in the age of iot and developing frameworks for securing smart devices and networks," *Journal of Computer Science and Technology Application*, vol. 2, no. 1, pp. 46–54, 2025.

[14] P. Y. Agustia Pratama, "Digital marketing transformation in business: A systematic literature review on trends, challenges, and strategic impacts," *International Journal of Smart Business and Technology*, 2025.

[15] S. Syawaluddin, D. Amanda, R. Irawan, B. Sitio, and S. Sumitro, "Digital transformation in marketing 2025: The role of artificial intelligence in improving customer experience," *Jurnal Sains, Teknologi & Komputer*, 2026.

[16] M. S. Nguyen, "Bibliometric insights into the evolution of digital marketing trends," *Business Perspectives*, vol. 20, no. 2, 2024.

[17] D. B. Sasongko and J. P. Nugraha, "The influence of digital advertising, seo, and social media interaction on fresh fish sales," *Jurnal Informasi dan Teknologi*, 2025.

[18] Y. K. Sinaga, R. W. Sipayung, H. Herman, A. M. Nainggolan, M. Ngongo, E. Fatmawati, and N. V. Thao, "Enhancing english vocabulary through mobile legends: Insights from efl students," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 7, no. 1, pp. 192–205, 2025.

[19] A. R. A. Wicaksono and T. Endrawati, "Social media marketing, content marketing, email marketing, and seo impact on employee engagement and financial performance in indonesian start-up companies," *West Science Interdisciplinary Studies*, 2025.

[20] D. Sudiantini, J. Danu, S. Setyakinasti, S. A. Permatasari, M. L. Ottay, and C. A. Putri, "The influence of business intelligence on improving marketing performance in the digital era," *Sentri: Jurnal Riset Ilmiah*, 2024.

[21] S. Watini, Q. Aini, U. Rahardja, N. P. L. Santoso, and D. Apriliasari, "Class dojolms in the interactive learning of paud educators in the disruption era 4.0," *Journal of Innovation in Educational and Cultural Research*, vol. 3, no. 2, pp. 215–225, 2022.

[22] C. d. S. Robusti, A. B. A. Avelar, M. C. Farina, and C. A. Gananca, "Blockchain and smart contracts: transforming digital entrepreneurial finance and venture funding," *Journal of Small Business and Enterprise Development*, vol. 32, no. 3, pp. 739–761, 2025.

[23] S.-Y. Lin, L. Zhang, J. Li, L.-l. Ji, and Y. Sun, "A survey of application research based on blockchain smart contract," *Wireless Networks*, vol. 28, no. 2, pp. 635–690, 2022.

[24] A. Das, "Developing dynamic digital capabilities in micro-multinationals through platform ecosystems: assessing the role of trust in algorithmic smart contracts," *Journal of International Entrepreneurship*, vol. 21, no. 2, pp. 157–179, 2023.

[25] H. Purnomo, K. D. Hartomo, U. Rahardja, A. Ramadan *et al.*, "The impact of smart contracts on cyberpreneurship in contemporary business marketing," in *2024 3rd International Conference on Creative Communication and Innovative Technology (ICCIT)*. IEEE, 2024, pp. 1–6.

[26] S. L. Sitorus, R. T. H. Safariningsih, A. H. A. N. Karsa, M. A. Komara, and R. Evans, "Optimizing smart contracts and blockchain for sustainable digital fashionpreneurship," *Blockchain Frontier Technology*, vol. 5, no. 1, pp. 37–48, 2025.

[27] A. Chowdhury, "Vyoma commerce: a blockchain-based decentralized architecture to combat fraud and enhance security and trust in bangladesh's e-commerce ecosystem leveraging smart contracts, supply chain transparency, and digital identity," *Journal of Electrical Systems and Information Technology*, vol. 12, no. 1, p. 57, 2025.

[28] B. Dash, M. F. Ansari, P. Sharma, and S. Swayamsiddha, "Future ready banking with smart contracts-cbdc and impact on the indian economy," *International Journal of Network Security and Its Applications*, vol. 14, no. 5, pp. 39–49, 2022.

[29] M. M. Siahaan, A. Sijabat, H. Samosir, R. Purba, and R. F. Terizla, "Enhancing hots and entrepreneurial competencies through avnet academic applications in english learning," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 7, no. 1, pp. 206–216, 2025.

[30] O. Elias, O. J. Awotunde, O. I. Oladepo, P. F. Azuikpe, O. A. Samson, O. R. Oladele, and O. O. Ogunruku, "The evolution of green fintech: Leveraging ai and iot for sustainable financial services and smart contract implementation," *World Journal of Advanced Research and Reviews*, vol. 23, no. 1, pp. 2710–2723, 2024.

[31] A. Alqarni, "A blockchain-based solution for transparent intellectual property rights management: smart contracts as enablers," *Kybernetes*, vol. 54, no. 13, pp. 7380–7407, 2025.

[32] N. Ani, S. Millah, and P. A. Sunarya, "Optimizing online business security with blockchain technology,"

Startupreneur Business Digital (SABDA Journal), vol. 3, no. 1, pp. 67–80, 2024.

[33] H. H. Adinugraha, S. M. Marier, and R. Andrean, "An islamic legal review of smart contract regulation in digital economic transactions: A comparative study between indonesia and china," *Journal of Islamic Law on Digital Economy and Business*, pp. 1–17, 2025.

[34] B. C. Ubamadu, D. Bihani, A. I. Daraojimba, G. O. Osho, J. O. Omisola, and E. A. Etukudoh, "Optimizing smart contract development: A practical model for gasless transactions via facial recognition in blockchain," *Int. J. Multidiscip. Res. Growth Eval*, vol. 4, no. 1, pp. 978–989, 2022.

[35] I. D. Utama, P. Prabowo, and Z. Mohd, "Integrating business courses mentorship programs and investment to enhance entrepreneurial opportunities," *Aptisi Transactions on Technopreneurship (ATT)*, vol. 7, no. 1, pp. 228–239, 2025.

[36] Y. Zhao and J. Qiu, "Decentralized governance in action: A governance framework of digital responsibility in startups," *Journal of Responsible Technology*, vol. 21, p. 100107, 2025.

[37] A. Talha Talukder, M. A. I. Mahmud, A. Sultana, T. H. Pranto, A. B. Haque, and R. M. Rahman, "A customer satisfaction centric food delivery system based on blockchain and smart contract," *Journal of Information and Telecommunication*, vol. 6, no. 4, pp. 501–524, 2022.

[38] H. Halaburda, N. Levina, and S. Min, "Digitization of transaction terms within tce: Strong smart contract as a new mode of transaction governance," *MIS Quarterly*, vol. 48, no. 2, pp. 825–846, 2024.

[39] H. R. Dananjaya, M. Fabio, M. Fakhrezzy, C. C. Putri *et al.*, "Coordination of global approach for blockchain supply chains," *Blockchain Frontier Technology*, vol. 2, no. 1, pp. 72–83, 2022.

[40] K. F. Oguntegbe, N. Di Paola, and R. Vona, "Traversing the uncommon boulevard: entrepreneurial trajectory of decentralised autonomous organisations (daos)," *Technology Analysis & Strategic Management*, vol. 38, no. 3, pp. 309–325, 2026.

[41] A. Fitriani and F. Simon, "Influence of macroeconomics factors, profitability, and stock trading volume on stock prices in the years 2019–2021," *APTISI Transactions on Management*, vol. 8, no. 1, pp. 14–23, 2024.

[42] E. Demirel, S. Karagöz Zeren, and K. Hakan, "Smart contracts in tourism industry: a model with blockchain integration for post pandemic economy," *Current Issues in Tourism*, vol. 25, no. 12, pp. 1895–1909, 2022.

[43] R. L. Carlos, E. B. de Souza, and C. A. Mattos, "Enhancing circular economy practices through the adoption of digital technologies," *Business Strategy & Development*, vol. 7, no. 1, p. e330, 2024.

[44] C. Bellavitis, C. Fisch, and P. P. Momtaz, "The rise of decentralized autonomous organizations (daos): a first empirical glimpse," *Venture Capital*, vol. 25, no. 2, pp. 187–203, 2023.

[45] W. Naeem, M. A. Butt, and U. Javeid, "From entrepreneurship theory to startup execution: A simulation-based benchmark analysis of ai-enhanced venture decision systems in early-stage business performance," *Social Science Review Archives*, vol. 4, no. 1, pp. 4065–4075, 2026.

[46] V. Natanelov, S. Cao, M. Foth, and U. Dulleck, "Blockchain smart contracts for supply chain finance: Mapping the innovation potential in australia-china beef supply chains," *Journal of Industrial Information Integration*, vol. 30, p. 100389, 2022.

[47] OECD, *Smart City Data Governance: Challenges and the Way Forward*, ser. OECD Urban Studies. Paris: OECD Publishing, 2023. [Online]. Available: https://doi.org/10.1787/e57ce301-en

[48] I. Alim, N. Imtiaz, A. Al Prince, and M. A. Hasan, "Ai and blockchain integration: Driving strategic business advancements in the intelligent era," *Journal of Engineering and Computational Intelligence Review*, vol. 3, no. 2, pp. 38–50, 2025.

[49] H. Taherdoost and M. Madanchian, "Blockchain-based new business models: A systematic review," *Electronics*, vol. 12, no. 6, p. 1479, 2023.

[50] Q. Aini, D. Manongga, U. Rahardja, I. Sembiring, and Y.-M. Li, "Understanding behavioral intention to use of air quality monitoring solutions with emphasis on technology readiness," *International Journal of Human–Computer Interaction*, pp. 1–21, 2024.

[51] T. Hongsuchon, U. Rahardja, A. Khan, T.-H. Wu, C.-W. Hung, R.-H. Chang, C.-H. Hsu, and S.-C. Chen, "Brand experience on brand attachment: The role of interpersonal interaction, feedback, and advocacy," *Emerging Science Journal*, vol. 7, no. 4, pp. 1232–1246, 2023.