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Systematic Review

Blockchain Technology and Smart Contracts in Decentralized Governance Systems

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Abstract: The aim of our systematic review was to inspect the recently published literature on decentralized governance systems and integrate the insights it articulates on blockchain technology and smart contracts by employing Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines. Throughout January and May 2022, a quantitative literature review of ProQuest, Scopus, and the Web of Science databases was carried out, with search terms including "city" + "blockchain technology", "smart contracts", and "decentralized governance systems". As the analyzed research studies were published between 2016 and 2022, only 371 sources satisfied the eligibility criteria. A Shiny app was harnessed for the PRISMA flow diagram to include evidence-based acquired and handled data. Analyzing the most recent and relevant sources and leveraging screening and quality assessment tools such as AMSTAR, Dedoose, Distiller SR, ROBIS, and SRDR, we integrated the core outcomes and robust correlations related to smart urban governance. As data visualization tools, for initial bibliometric mapping dimensions were harnessed, together with layout algorithms provided by VOSviewer. Future research should investigate smart contract governance of blockchain applications and infrastructure using decision-making tools and spatial cognition algorithms.

Keywords: blockchain technology; smart contract; decentralized governance system; urban sensing technology; smart city analytics

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1. Introduction

Smart contracts, by integrating process automation, spatial analytics tools, computer-generated virtual data, and cognitive technologies (Hawkins 2022a; Morales et al. 2022), carry out collaborative networks and distributed governance on blockchain-based platforms. Blockchain technology, by leveraging contextual awareness, data tracking apps, and spatial analytics, facilitates digital transparent trusted exchanges and transactions. Using automated collaborative processes and behaviours, data visualization tools, spatial intelligence technology, and simulation modeling software (Bin 2022; Hamilton 2022; Priem 2021), blockchain technologies can shape public management structures across the smart governance system.

The aim of our systematic review was to inspect the recently published literature on decentralized governance systems and integrate the insights it articulates on blockchain technology and smart contracts. The actuality and novelty of our systematic review are

brought about by addressing the relationship between blockchain technology, smart contracts, and decentralized governance systems (Carter 2022; Johnson and Nica 2021; Rowland 2022), which is pivotal in coherent forecasting and algorithmic monitoring operational performances. The implementation of current smart solutions in public governance and local communities' development systems remains an essential challenge for achieving effective results in the digital transformation of utilities, overall well-being in smart cities, as well as high quality of governance in distributive policy (Mishchuk et al. 2019; Nevado Gil et al. 2020; Yakymova et al. 2022). Our specific contribution is to show how smart urban governance develops on interconnected sensor networks, data-driven Internet of Things systems, and data monitoring algorithms (Bai et al. 2022; Khan et al. 2020; Kundu 2019; Sifah et al. 2020; Sun et al. 2016), deploying virtual navigation tools, mobile-geofencing technology, data-mining techniques, and deep reinforcement learning. Similarities with previously published sources encompass analyses on how urban sensing technologies (Hawkins 2022b; Kliestik et al. 2022; Popescu et al. 2022; Watson 2022) integrate geospatial big data analytics, Internet of Things sensors, and smart city software systems (Beck et al. 2018; Howell and Potgieter 2021; Lin et al. 2022; Marsal-Llacuna 2020; Rikken et al. 2019; Małkowska et al. 2021; Wong et al. 2020), while dissimilarities include our integration of the literature on blockchain technology and smart contracts that require sustainable urban governance networks, Internet of Things sensing infrastructures, and spatial cognition algorithms (Alasbali et al. 2022; Hooper and Holtbrügge 2020; Lăzăroiu and Harrison 2021; Mora et al. 2021; Reinsberg 2021; Rozas et al. 2021) so as to enable decentralized governance systems by use of wireless sensor-based applications, data-driven planning technologies (Kobylińska and Lavios 2020; Liu et al. 2021), and urban big data analytics, thus configuring smart city analytics, logistics, planning, and management (Bai et al. 2022; Khan et al. 2020; Nica 2021; Sifah et al. 2020; Sotoudehnia 2021; Rymarczyk 2020; Sun et al. 2016). The research problem is whether sustainable urban technologies and digital governance networks (Blake 2022; Dawson 2022; Wallace and Lăzăroiu 2021) integrate Internet of Things-connected sensors to assist blockchain technology and smart contracts in decentralized governance systems (Beck et al. 2018; Blakemore and Kral 2021; Hassija et al. 2021; Murray et al. 2021; Shan et al. 2021; Viano et al. 2022; Wong et al. 2020).

Research Problem 1: Decentralized and autonomous blockchain technology, by leveraging cognitive enhancement systems, computer vision algorithms, transactional data, and business intelligence analytics, can assist smart governance.

Research Problem 2: Smart contracts are pivotal in transactions on blockchain platforms, by harnessing data visualization tools, text mining and analytics, and deep learning algorithms and configuring cutting-edge governance arrangements.

Research Problem 3: Agreed-upon transactions configured by smart contracts, using deep and machine learning algorithms, real-time predictive analytics, and spatial computing technology, articulate the blockchain economy as a decentralized self-governing entity.

The manuscript is organized as follows: methodology (Section 2), smart contract governance of blockchain applications and infrastructure (Section 3), smart contract-based blockchain governance decision-making and behavior (Section 4), decentralized applications and smart contracts enabled by blockchain technology (Section 5), discussion (Section 6), conclusions (Section 7), specific contributions to the literature (Section 8), limitations and further directions of research (Section 9), and practical implications (Section 10).

2. Methodology

Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines were employed (Andronie et al. 2021). Throughout January and May 2022, a quantitative literature review of ProQuest, Scopus, and the Web of Science databases was carried out, with search terms including "city" + "blockchain technology", "smart contracts", and "decentralized governance systems". As the analyzed research was published between 2016 and 2022, only 371 sources satisfied the eligibility criteria. Excluded, out of scope, and insufficiently detailed records, together with limited rigor, have resulted in a selection of

39 predominantly empirical sources (Tables 1 and 2). A Shiny app was harnessed for the PRISMA flow diagram to include evidence-based acquired and handled data. Analyzing the most recent and relevant sources and leveraging screening and quality assessment tools such as AMSTAR (Assessing the Methodological Quality of Systematic Reviews), Dedoose (investigating qualitative and mixed methods research), Distiller SR (that harnesses artificial intelligence and data-driven workflows, automating reference gathering, screening, and assessment), ROBIS (bias risk assessment tool in systematic reviews), and SRDR (Systematic Review Data Repository), we integrated the core outcomes and robust correlations related to smart urban governance. As data visualization tools, for initial bibliometric mapping dimensions was harnessed, together with layout algorithms provided by VOSviewer with respect to co-authorship (Figure 1), citation (Figure 2), bibliographic coupling (Figure 3), co-citation (Figure 4), and PRISMA flow diagram indicating the search outcomes and screening (Figure 5).

Table 1. Topics and types of scientific products identified and selected.

Topic	Identified	Selected
city + blockchain technology	128	15
city + smart contracts	122	14
city + decentralized governance systems	121	12
Type of paper		
Original research	266	36
Review	27	3
Conference proceedings	36	0
Book	19	0
Editorial	23	0

Source: Processed by the authors. Some topics overlap.

Table 2. General synopsis of evidence as regards focus topics and descriptive outcomes (research findings).

Blockchain technologies can be harnessed in the smart governance of data-driven cities. Blockchain-based smart governance systems entail public engagement for scalable and efficient data sharing through infrastructure maintenance.	(Bai et al. 2022; Khan et al. 2020; Kundu 2019; Sifah et al. 2020; Sun et al. 2016)
Seamless data sharing reliability, scalability, and interoperability are enabled by the decentralized system of blockchain technology and integrated in smart city planning, leading to informed decisions and actions. Smart contracts are pivotal in transactions on blockchain platforms, configuring cutting-edge governance arrangements.	(Beck et al. 2018; Howell and Potgieter 2021; Lin et al. 2022; Marsal-Llacuna 2020; Rikken et al. 2019; Wong et al. 2020)
Internet of Things-driven smart city applications assimilate scalable networked interoperability across urban environments and data resource management through self-governing and immutable transactions. Blockchain-enabled software tools are pivotal in decentralized algorithmic governance infrastructures.	(Alasbali et al. 2022; Hooper and Holtbrügge 2020; Lăzăroiu and Harrison 2021; Mora et al. 2021; Reinsberg 2021; Rozas et al. 2021)
Smart city governance enables collaborative participation through decision-making tools and spatial cognition algorithms. Blockchain technology can enable smart governance using data-driven technologies and value-making processes.	(Bai et al. 2022; Khan et al. 2020; Nica 2021; Sifah et al. 2020; Sotoudehnia 2021; Sun et al. 2016)
The distributed structure of blockchain technology enables smart contracts. The blockchain technology can shape public management structures across the smart governance system through automated collaborative processes and behaviours.	(Beck et al. 2018; Blakemore and Kral 2021; Hassija et al. 2021; Murray et al. 2021; Shan et al. 2021; Viano et al. 2022; Wong et al. 2020)

Table 2. *Cont.*

Robust and scalable blockchain-based interoperable infrastructure in the public governance requires coherent resource management mechanisms enabled by smart contracts. Blockchain technology leverages decentralized applications in smart contracts, reconfiguring organizational structures and business models.	(Akram et al. 2020; Chang and Chen 2020; Dursun and Üstündağ 2021; Gray and Kovacova 2021; Rozas et al. 2021; Singh and Chopra 2020; Zachariadis et al. 2019)
Data-driven cities attempt to articulate smart governance so as to increase transparency and trust throughout urban transactions and public services. Smart governance records and transactions can be interconnected by blockchain-based decentralized networks due to their real-time tracking capabilities, improving public service transparency.	(Bai et al. 2022; Kaur et al. 2021; Khan et al. 2020; Kundu 2019; Mulligan 2021; Sun et al. 2016; Wong et al. 2020)
Blockchain-enabled smart contracts articulate democratized governance structures, shaping operational decisions. Blockchain technology facilitates digital transparent trusted exchanges and transactions.	(Beck et al. 2018; Fiorentino and Bartolucci 2021; Khan et al. 2020; Murray et al. 2021; Reinsberg 2019)
Transparent and decentralized blockchain technology can shape sustainable urban environment in smart cities through data center networks. Autonomous blockchain-enabled smart contracts articulate enhanced cooperation across decentralized governance platforms in terms of power distribution.	(Bagloee et al. 2021; Bhushan et al. 2020; Evans and Horak 2021; Ozdemir et al. 2020; Reinsberg 2021; Sinha and Roy Chowdhury 2021)

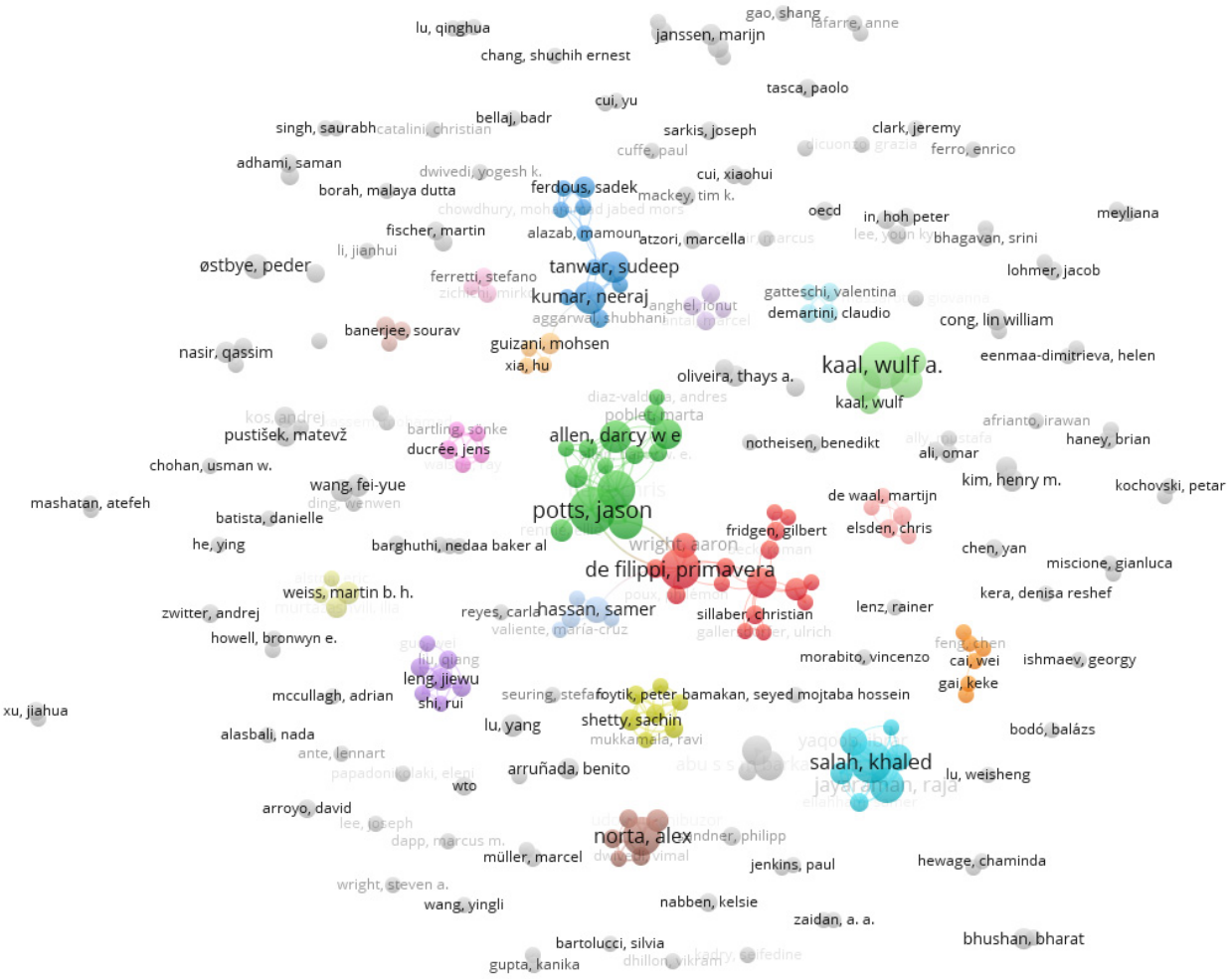

Figure 1. VOSviewer mapping of blockchain technology and smart contracts in decentralized governance systems regarding co-authorship.

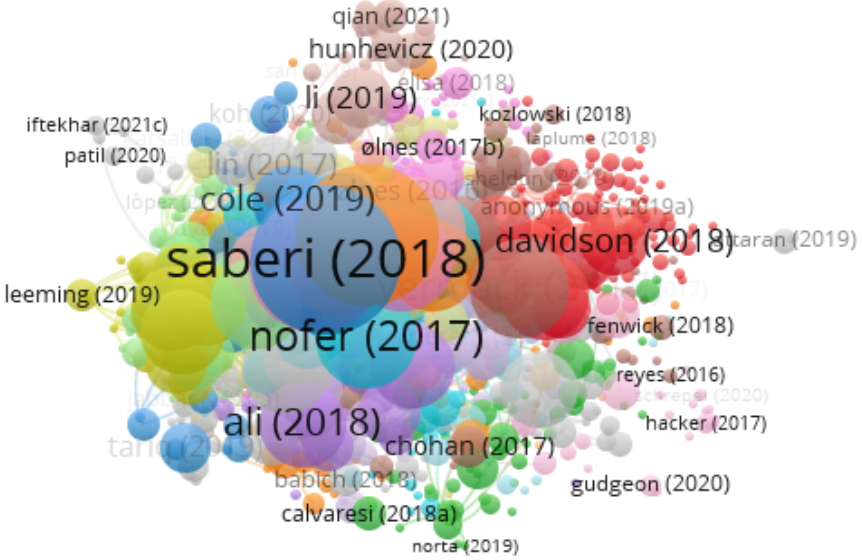

Figure 2. VOSviewer mapping of blockchain technology and smart contracts in decentralized governance systems regarding citation.

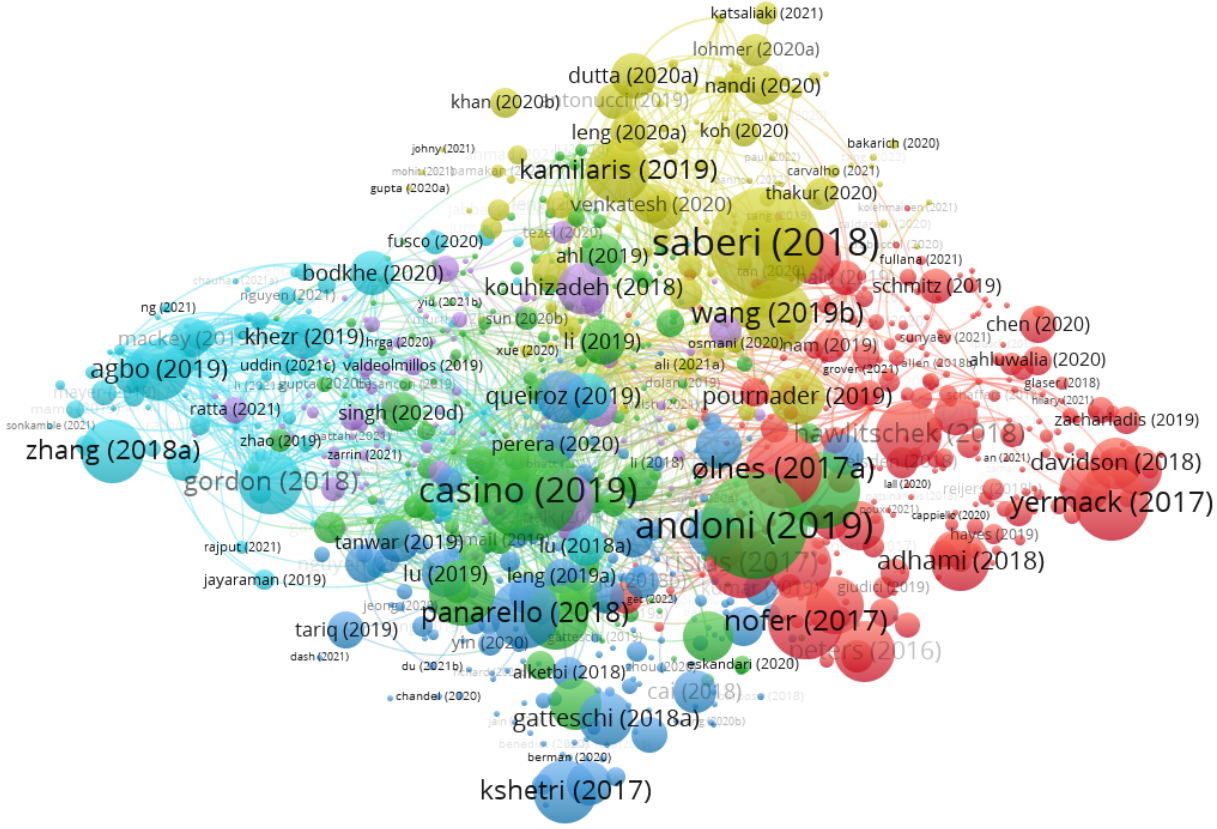

Figure 3. VOSviewer mapping of blockchain technology and smart contracts in decentralized governance systems regarding bibliographic coupling.

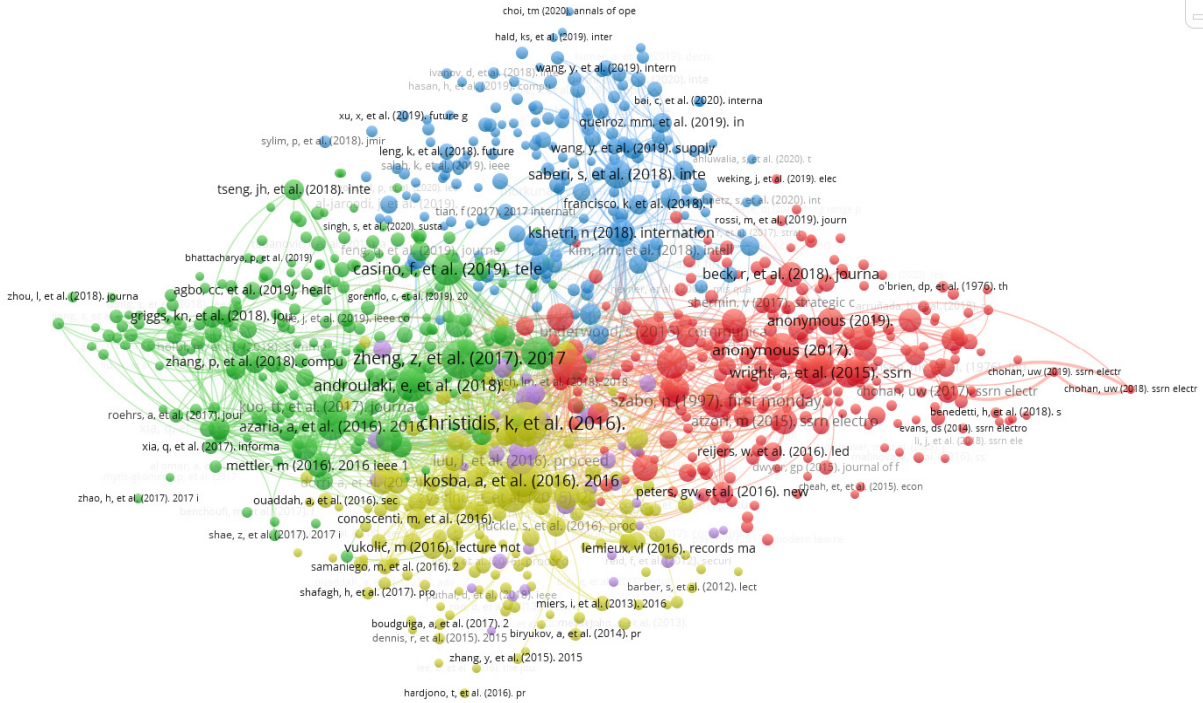

Figure 4. VOSviewer mapping of blockchain technology and smart contracts in decentralized governance systems regarding co-citation.

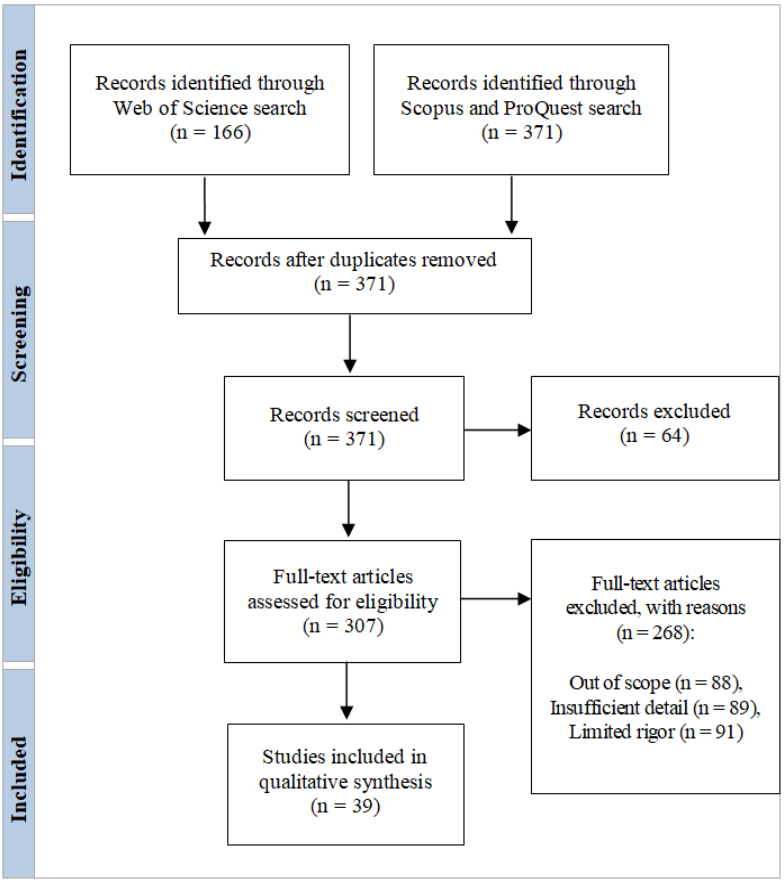

Figure 5. PRISMA flow diagram describing the search results and screening.

Citation correlations have covered how blockchain technology and applications, by leveraging digital twinning, analytic decision models, and visual recognition tools, can reconfigure organizational governance mechanisms. Using blockchain technology and edge computing, citizen participation in smart urban planning requires data management capabilities. Blockchain technology, by the use of spatial computing technology, interconnected virtual simulations, and geolocation data, leverages decentralized applications in smart contracts, reconfiguring organizational structures and business models. Blockchain technology, by deploying spatial data mining, cognitive technologies, and virtual reality tools, assists networked cyber-physical systems and smart contracts in seamless data sharing and infrastructure mapping.

3. Smart Contract Governance of Blockchain Applications and Infrastructure

Decentralized and autonomous blockchain technology can assist smart governance (Bai et al. 2022; Khan et al. 2020; Kundu 2019; Sifah et al. 2020; Sun et al. 2016) in transparent citizen participation by record immutability and thorough transparency, leveraging cognitive enhancement systems, computer vision algorithms, transactional data, and business intelligence analytics. Blockchain technologies can be harnessed in the smart governance of data-driven cities, which have become a driving factor of technological modernization, supporting innovation and sustainable growth potential both at microeconomic and macroeconomic levels (Andrijauskiene et al. 2021; Markauskas and Baliute 2021; Giza and Wilk 2021). Internet of Things devices can be assisted by blockchain technology in trust-free transactions, and smart contracts can be integrated in computing codes to carry out the agreement obligations by employing biometrics data fusion, blockchain token-based digital assets, spatial computing technology, and machine vision algorithms. Blockchain technology and edge computing can further open governance in terms of scalable authentication and authorization during participatory transactions by harnessing synthetic data, simulation modeling, predictive maintenance, and ambient scene detection. Blockchain-based smart governance systems entail public engagement for scalable and efficient data sharing through infrastructure maintenance, deploying data computing capabilities, distributed ledger technologies, visual analytics, and smart connected devices. Blockchain-based citizen engagement and transactions require public participatory management in conformity with data processing capacity by the use of cohesive data analysis, logistics intelligence, cognitive technologies, and visual modeling capabilities.

Smart contract governance of blockchain applications and infrastructure integrates decentralized decision-making processes and coordination mechanisms (Beck et al. 2018; Howell and Potgieter 2021; Lin et al. 2022; Marsal-Llacuna 2020; Rikken et al. 2019; Wong et al. 2020) with respect to autonomous data, products, services, and actions. The decentralized nature of blockchain optimizes smart city self-governance and empowers citizens through decision support tools, network modeling, and geolocation data. Seamless data-sharing reliability, scalability, and interoperability are enabled by the decentralized system of blockchain technology and integrated in smart city planning, leading to informed decisions and actions. Decentralized decision making in the blockchain economy furthers smart contract-based transaction data by the use of analytical artificial intelligence, spatial computing technology, and predictive algorithms. Blockchain technology and applications can reconfigure organizational governance mechanisms (Crișan-Mitra et al. 2020; Glogovețan et al. 2022; Lăzăroiu et al. 2020a, 2020b) in terms of transaction upgrading by leveraging digital twinning, analytic decision models, and visual recognition tools. Smart contracts are pivotal in transactions on blockchain platforms, configuring cutting-edge governance arrangements by harnessing data visualization tools, text mining and analytics, and deep learning algorithms.

Smart contract tools can integrate blockchain technology (Alasbali et al. 2022; Hooper and Holtbrügge 2020; Bal-Domańska et al. 2020; Lăzăroiu and Harrison 2021; Mora et al. 2021; Reinsberg 2021; Rozas et al. 2021) in public service delivery, which can positively affect local and regional competitiveness (Roszko-Wójtowicz and Grzelak 2021) using

cognitive automation tools, image processing computational algorithms, and machine learning capabilities. Blockchain technology and applications decrease transaction costs in public governance and international business by leveraging data mining techniques, deep and machine learning algorithms, and decision intelligence and modeling. Internet of Things-driven smart city applications assimilate scalable networked interoperability across urban environments and data resource management using self-governing and immutable transactions by deploying decision support tools, computer-vision techniques, and visual data mining. Using decentralized actions and processes across interoperable blockchain-based algorithmic governance, smart contracts reduce transaction costs and drive performance at scale in blockchain-based virtual economy by the use of transaction geolocation data, visual analytics, and cognitive computing systems. Blockchain-enabled software tools are pivotal in decentralized algorithmic governance infrastructures in terms of transaction analytics, decentralized payment systems, and real-time performance data (Table 3).

Table 3. Synopsis of evidence as regards focus topics and descriptive outcomes.

Decentralized and autonomous blockchain technology can assist smart governance in transparent citizen participation by record immutability and thorough transparency, leveraging cognitive enhancement technologies, computer vision algorithms, transactional data, and business intelligence analytics.	(Bai et al. 2022; Khan et al. 2020; Kundu 2019; Sifah et al. 2020; Sun et al. 2016)
Smart contract governance of blockchain applications and infrastructure integrates decentralized decision-making processes and coordination mechanisms with respect to autonomous data, products, services, and actions.	(Beck et al. 2018; Howell and Potgieter 2021; Lin et al. 2022; Marsal-Llacuna 2020; Rikken et al. 2019; Wong et al. 2020)
Smart contract tools can integrate blockchain technology in public service delivery through cognitive automation tools, image processing computational algorithms, and machine learning capabilities.	(Alasbali et al. 2022; Hooper and Holtbrügge 2020; Lăzăroiu and Harrison 2021; Mora et al. 2021; Reinsberg 2021; Rozas et al. 2021)

4. Smart Contract-Based Blockchain Governance Decision Making and Behavior

Data collection and processing by leveraging blockchain technology, in addition to decision support tools, transaction analytics, and artificial vision systems (Bai et al. 2022; Khan et al. 2020; Nica 2021; Sifah et al. 2020; Sotoudehnia 2021; Sun et al. 2016), are pivotal in smart city governance. Citizen participations in smart urban planning using blockchain technology and edge computing require data management capabilities. Smart city governance enables collaborative participation through decision-making tools and spatial cognition algorithms. Distributed computing and data monitoring algorithms enable congruence of blockchain-based democratized nodes by the use of predictive modeling, cognitive computing systems, and virtual connectivity tools. Blockchain technology can enable smart governance through data-driven technologies and value-making processes, optimizing public services by the use of digital leadership and empowerment using transparent data management.

Blockchain technology can assist public sector entities in integrating smart governance (Beck et al. 2018; Blakemore and Kral 2021; Hassija et al. 2021; Murray et al. 2021; Shan et al. 2021; Viano et al. 2022; Wong et al. 2020) in terms of operational efficiency and costs, enhanced security, affordable transparent edge-computing infrastructure and immutable data architecture. Smart cities can deploy blockchain technology for decentralized transparent digital transformation through transaction record immutability by harnessing simulation modeling algorithms, spatial computing tools, and dynamic routing technology. Agreed-upon transactions configured by smart contracts articulate the blockchain economy

as a decentralized self-governing entity by using deep and machine learning algorithms, real-time predictive analytics, and spatial computing technology. The distributed structure of blockchain technology enables smart contracts by the use of cloud and edge computing technologies, virtual navigation tools, and geospatial mapping technology. The blockchain technology can shape public management structures across the smart governance system using automated collaborative processes and behaviours, data-visualization tools, spatial-intelligence technology, and simulation-modeling software (Kachniewska 2020). Blockchain technology supports digitally enabled public services and social innovation tools using tokenization mechanisms and digital asset transactions that can optimize socio-economic interactions, citizen participation, public governance, and democratic processes.

Smart contract-based blockchain governance decision making and behavior (Akram et al. 2020; Chang and Chen 2020; Dursun and Üstündağ 2021; Gray and Kovacova 2021; Rozas et al. 2021; Singh and Chopra 2020; Zachariadis et al. 2019) can strengthen decentralized policy-based management networks using interconnected decision-making processes, remote sensing tools, and cognitive-computing systems. Robust and scalable blockchain-based interoperable infrastructure in the public governance requires coherent resource management mechanisms enabled by smart contracts by leveraging spatial intelligence tools, data-sharing technologies, and real-time predictive analytics. Blockchain platforms redesign financial services and infrastructures of payment systems, leading to decentralized governance practices and control mechanisms through visual analytics tools, machine learning-based predictive technologies, and connected data governance. Smart contracts carry out collaborative networks and distributed governance on blockchain-based platforms by integrating process automation, spatial-analytics tools, computer-generated virtual data, and cognitive technologies. Blockchain technology leverages decentralized applications in smart contracts, reconfiguring organizational structures and business models by the use of spatial computing technology, interconnected virtual simulations, and geolocation data. Persistent, interoperable, and immutable blockchain-based governance enables trackable participative organizational and collaborative processes by using data visualization tools, spatial intelligence technology, and digital twin technologies (Table 4).

Table 4. Synopsis of evidence as regards focus topics and descriptive outcomes.

Data collection and processing by leveraging blockchain technology, in addition to decision support tools, transaction analytics, and artificial vision systems, are pivotal in smart city governance.	(Bai et al. 2022; Khan et al. 2020; Nica 2021; Sifah et al. 2020; Sotoudehnia 2021; Sun et al. 2016)
Blockchain technology can assist public sector entities in integrating smart governance in terms of operational efficiency and costs, enhanced security, affordable transparent edge-computing infrastructure, and immutable data architecture.	(Beck et al. 2018; Blakemore and Kral 2021; Hassija et al. 2021; Murray et al. 2021; Shan et al. 2021; Viano et al. 2022; Wong et al. 2020)
Smart contract-based blockchain governance decision making and behavior can strengthen decentralized policy-based management networks by using interconnected decision-making processes, remote sensing tools, and cognitive-computing systems.	(Akram et al. 2020; Chang and Chen 2020; Dursun and Üstündağ 2021; Gray and Kovacova 2021; Rozas et al. 2021; Singh and Chopra 2020; Zachariadis et al. 2019)

5. Decentralized Applications and Smart Contracts Enabled by Blockchain Technology

Blockchain-based smart contracts and decentralized applications (Bai et al. 2022; Kaur et al. 2021; Khan et al. 2020; Kundu 2019; Mulligan 2021; Sun et al. 2016; Wong et al. 2020) can increase trust in computationally networked urbanism by harnessing data visualization tools, spatial data mining, and machine learning techniques. Blockchain technology can be instrumental in smart city development, decreasing operational costs using business-transaction automation in digital commercial interactions. Data-driven cities attempt to articulate smart governance so as to increase transparency and trust throughout urban

transactions and public services and, consequently, facilitate citizen involvement in decision making processes. Continuous blockchain-based smart infrastructure maintenance can shape real-time citizen involvement and public administration monitoring in the decision-making process by using computer-based cognitive tools, vision data processing, and cognitive artificial intelligence algorithms. Blockchain technology assists networked cyber-physical systems and smart contracts in seamless data sharing and infrastructure mapping by deploying spatial-data mining, cognitive technologies, and virtual reality tools. Smart governance records and transactions can be interconnected by blockchain-based decentralized networks due to their real-time tracking capabilities, improving public service transparency.

Smart contracts enable decentralized blockchain-based governance mechanisms and decision making (Beck et al. 2018; Fiorentino and Bartolucci 2021; Khan et al. 2020; Murray et al. 2021; Reinsberg 2019) with respect to autonomous transactions by harnessing mobile geofencing technology, predictive and visual analytics tools, and blockchain-driven data accuracy. Blockchain technology and edge computing can integrate data-driven Internet of Things systems for transparent data management and open governance across smart city environments. Blockchain-enabled smart contracts articulate democratized governance structures, shaping operational decisions by using remote sensing tools, data computing capabilities, and interoperable virtual networks. Blockchain-based smart contracts constitute digital urban governance tools integrating transparent capabilities for data-driven cities and the public sector. Blockchain technology facilitates digitally transparent trusted exchanges and transactions by leveraging contextual awareness, data tracking apps, and spatial analytics.

Decentralized applications and smart contracts enabled by blockchain technology (Bagloee et al. 2021; Bhushan et al. 2020; Evans and Horak 2021; Ozdemir et al. 2020; Reinsberg 2021; Sinha and Roy Chowdhury 2021) enhanced the public governance of smart cities by using computer vision algorithms, 3D modeling and digital twin-based intelligent tools, and geospatial mapping technology. As underlying operating systems, blockchain urban applications in the public governance of smart cities empower transparent citizen participation by employing image recognition tools, cognitive computing systems, and behavioral modeling technologies. Transparent and decentralized blockchain technology can shape sustainable urban environment in smart cities through data center networks by the use of ambient scene detection, visual analytics, and data-sharing technologies. Trustworthy and secured blockchain technology-based smart contracts result in business process harmonization by integrating digital twin technologies, remote sensing systems, and virtual-connectivity tools. Autonomous blockchain-enabled smart contracts articulate enhanced cooperation across decentralized governance platforms in terms of power distribution using spatial computing technology, data visualization tools, and behavioral predictive analytics (Table 5).

Table 5. Synopsis of evidence as regards focus topics and descriptive outcomes.

Blockchain-based smart contracts and decentralized applications can increase trust in computationally networked urbanism by harnessing data visualization tools, spatial data mining, and machine learning techniques.	(Bai et al. 2022; Kaur et al. 2021; Khan et al. 2020; Kundu 2019; Mulligan 2021; Sun et al. 2016; Wong et al. 2020)
Smart contracts enable decentralized blockchain-based governance mechanisms and decision making as regards autonomous transactions by harnessing mobile geofencing technology, predictive and visual analytics tools, and blockchain-driven data accuracy.	(Beck et al. 2018; Fiorentino and Bartolucci 2021; Khan et al. 2020; Murray et al. 2021; Reinsberg 2019)
Decentralized applications and smart contracts enabled by blockchain technology enhanced public governance of smart cities through computer vision algorithms, 3D modeling and digital twin-based intelligent tools, and geospatial mapping technology.	(Bagloee et al. 2021; Bhushan et al. 2020; Evans and Horak 2021; Ozdemir et al. 2020; Reinsberg 2021; Sinha and Roy Chowdhury 2021)

6. Discussion

Smart urban governance develops on interconnected sensor networks, data-driven Internet of Things systems, and data monitoring algorithms (Bai et al. 2022; Khan et al. 2020; Kundu 2019; Sifah et al. 2020; Sun et al. 2016). Internet of Things-driven smart city applications, by deploying decision support tools, computer vision techniques, and visual data mining, assimilate scalable networked interoperability across urban environments and data resource management. Urban sensing technologies integrate geospatial big data analytics, Internet of Things sensors, and smart city software systems (Beck et al. 2018; Howell and Potgieter 2021; Lin et al. 2022; Marsal-Llacuna 2020; Rikken et al. 2019; Wong et al. 2020). Blockchain technology and smart contracts require sustainable urban governance networks (Akram et al. 2020; Chang and Chen 2020; Dursun and Üstündağ 2021; Gray and Kovacova 2021; Rozas et al. 2021; Singh and Chopra 2020; Zachariadis et al. 2019), Internet of Things sensing infrastructures, and spatial cognition algorithms (Alasbali et al. 2022; Hooper and Holtbrügge 2020; Lăzăroiu and Harrison 2021; Mora et al. 2021; Reinsberg 2021; Rozas et al. 2021) so as to enable decentralized governance systems (Bagloee et al. 2021; Bhushan et al. 2020; Evans and Horak 2021; Ozdemir et al. 2020; Reinsberg 2021; Sinha and Roy Chowdhury 2021) by the use of wireless sensor-based applications, data-driven planning technologies, and urban big data analytics (Bai et al. 2022; Kaur et al. 2021; Khan et al. 2020; Kundu 2019; Mulligan 2021; Sun et al. 2016; Wong et al. 2020), thus configuring smart city analytics, logistics, planning, and management (Bai et al. 2022; Khan et al. 2020; Nica 2021; Sifah et al. 2020; Sotoudehnia 2021; Sun et al. 2016). Transparent and decentralized blockchain technology, by the use of ambient scene detection, visual analytics, and data sharing technologies, can shape sustainable urban environment in smart cities using data center networks. Smart contract-based blockchain governance decision making and behavior, by using interconnected decision-making processes, remote sensing tools, and cognitive computing systems, can strengthen decentralized policy-based management networks. Sustainable urban technologies and digital governance networks integrate Internet of Things-connected sensors (Beck et al. 2018; Fiorentino and Bartolucci 2021; Khan et al. 2020; Murray et al. 2021; Reinsberg 2019) to assist blockchain technology and smart contracts in decentralized governance systems (Beck et al. 2018; Blakemore and Kral 2021; Hassija et al. 2021; Murray et al. 2021; Shan et al. 2021; Viano et al. 2022; Wong et al. 2020). Blockchain-enabled software tools are pivotal in terms of transaction analytics, decentralized payment systems, and real-time performance data in decentralized algorithmic governance infrastructures.

7. Conclusions

Significant research has analyzed how blockchain technology and applications can reconfigure organizational governance mechanisms. Our systematic literature review inspects significant published peer-reviewed evidence concerning interoperable blockchain-based algorithmic governance. Blockchain-based smart governance systems, by deploying data-computing capabilities, distributed ledger technologies, visual analytics, and smart connected devices, entail public engagement. Blockchain-based smart contracts and decentralized applications, by harnessing data visualization tools, spatial data mining, and machine learning techniques, can increase trust in computationally networked urbanism. We show how blockchain-based smart governance systems entail public engagement for scalable and efficient data. Decentralized decision making in the blockchain economy, by the use of analytical artificial intelligence, spatial computing technology, and predictive algorithms, furthers smart contract-based transaction data. Blockchain-enabled smart contracts, by applying remote sensing tools, data computing capabilities, and interoperable virtual networks, articulate democratized governance structures, shaping operational decisions. We clarify that seamless data-sharing reliability, scalability, and interoperability are enabled by the decentralized system of blockchain technology. By applying transaction geolocation data, visual analytics, and cognitive computing systems, smart contracts reduce transaction costs and drive performance at scale in blockchain-based virtual economy.

Trustworthy and secured blockchain technology-based smart contracts, by integrating digital twin technologies, remote sensing systems, and virtual connectivity tools, result in business process harmonization. The findings gathered from the above analyses clarify that smart contracts are pivotal in transactions on blockchain platforms. The distributed structure of blockchain technology, by the use of cloud and edge computing technologies, virtual navigation tools, and geospatial mapping technology, enables smart contracts. The decentralized nature of blockchain, by applting decision support tools, network modeling, and geolocation data, optimizes smart city self-governance and empowers citizens.

8. Specific Contributions to the Literature

This systematic review covers an emerging topic that has become the subject of focus (that is, the relationship between blockchain technology, smart contracts, and decentralized governance systems) that has not been addressed so far in the literature in terms of smart contract governance of blockchain applications and infrastructure, smart contract-based blockchain governance decision-making and behavior, and decentralized applications and smart contracts enabled by blockchain technology. No previous research has inspected how robust and scalable blockchain-based interoperable infrastructure in the public governance, by leveraging spatial intelligence tools, data sharing technologies, and real-time predictive analytics, requires coherent resource management mechanisms enabled by smart contracts. Decentralized applications and smart contracts enabled by blockchain technology, by using computer vision algorithms, 3D modeling and digital twin-based intelligent tools, and geospatial mapping technology, enhance public governance of smart cities. By deploying virtual navigation tools, mobile geofencing technology, data mining techniques, and deep reinforcement learning, coherent forecasting and algorithmic monitoring of operational performance can be carried out.

9. Limitations and Further Directions of Research

As limitations, by inspecting only original research and review articles published in journals indexed in ProQuest, Scopus, and the Web of Science between 2016 and 2022, relevant sources on smart contract-based blockchain governance decision making and behavior may have been omitted. Subsequent interest should be oriented towards how the blockchain technology can shape public management structures across the smart governance system. The scope of this systematic review does not advance decentralized decision making in the blockchain economy. Practical consequences would be how blockchain technology can enable smart governance by using data-driven technologies and value-making processes. Thus, blockchain technology and edge computing, by harnessing synthetic data, simulation modeling, predictive maintenance, and ambient scene detection, can further open governance. Smart contract tools, by applying cognitive automation tools, image processing computational algorithms, and machine learning capabilities, can integrate blockchain technology in public service delivery. Distributed computing and data monitoring algorithms, by the use of predictive modeling, cognitive computing systems, and virtual connectivity tools, enable the congruence of blockchain-based democratized nodes. Continuous blockchain-based smart infrastructure maintenance, by using computer-based cognitive tools, vision data processing, and cognitive artificial intelligence algorithms, can shape real-time citizen involvement and public administration monitoring in the decision-making process. Autonomous blockchain-enabled smart contracts, using spatial computing technology, data visualization tools, and behavioral predictive analytics, articulate enhanced cooperation across decentralized governance platforms in terms of power distribution. Academic implications of these investigations mainly encompass the need of advancing research on decentralized algorithmic governance infrastructures. Future research should investigate the smart contract governance of blockchain applications and infrastructure by using decision-making tools and spatial cognition algorithms. Blockchain-based citizen engagement and transactions, by the use of cohesive data analysis, logistics intelligence, cognitive technologies, and visual modeling capabilities, require

public participatory management. Subsequent analyses should develop on how data collection and processing are pivotal in smart city governance by leveraging blockchain technology, decision support tools, transaction analytics, and artificial vision systems. By using visual analytics tools, machine learning-based predictive technologies, and connected data governance, blockchain platforms redesign financial services and infrastructures of payment systems, leading to decentralized governance practices and control mechanisms. Attention should be directed to how smart contracts, by harnessing mobile geofencing technology, predictive and visual analytics tools, and blockchain-driven data accuracy, enable decentralized blockchain-based governance mechanisms and decision making with respect to autonomous transactions.

10. Practical Implications

Internet of Things devices, by employing biometrics data fusion, blockchain token-based digital assets, spatial computing technology, and machine vision algorithms, can be assisted by blockchain technology. Blockchain technology and applications, by leveraging data mining techniques, deep and machine learning algorithms, and decision intelligence and modeling, decrease transaction costs in public governance and international business. By harnessing simulation-modeling algorithms, spatial-computing tools, and dynamic-routing technology, smart cities can deploy blockchain technology for decentralized transparent digital transformation through transaction record immutability. Persistent, interoperable, and immutable blockchain-based governance, by using data visualization tools, spatial intelligence technology, and digital twin technologies, enables trackable participative organizational and collaborative processes. As underlying operating systems, by employing image recognition tools, cognitive computing systems, and behavioral modeling technologies, blockchain urban applications in the public governance of smart cities empower transparent citizen participation.

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