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Blockchain Technology for Secure Data Sharing: Review

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Abstract. *Data sharing is a critical thing of current digital ecosystems, facilitating seamless communique, collaboration, and innovation throughout numerous sectors, consisting of healthcare, finance, and supply chains. However, safety demanding situations including facts breaches, unauthorized get admission to, and privateness violations pose enormous risks, limiting the consider and willingness of agencies to proportion facts correctly. Traditional safety mechanisms frequently fall short in addressing these concerns, necessitating the adoption of superior answers.Blockchain era emerges as a transformative option to beautify records safety, integrity, and transparency in facts-sharing ecosystems. By leveraging decentralized ledgers, cryptographic hashing, and clever contracts, blockchain guarantees tamper-evidence statistics exchange at the same time as preserving privateness and get right of entry to control. This paper reviews the potential of blockchain as a steady data-sharing framework, studying its benefits, obstacles, and real-international applications. Furthermore, the have a look at explores how blockchain mitigates safety vulnerabilities, promotes trust, and fosters regulatory compliance in information-sharing environments. The evaluate concludes that at the same time as blockchain offers a promising approach to stable facts sharing, demanding situations together with scalability, regulatory alignment, and integration with present systems must be addressed to maximise its adoption. Future studies ought to attention on overcoming these boundaries and enhancing blockchain frameworks to make certain broader implementation across industries.*

Keywords: *Blockchain; Healthcare; IoT technology; Financial Sector; Data Security*

1. INTRODUCTION

The virtual age, data sharing has grow to be a crucial element across severa sectors, such as healthcare, finance, supply chains, and e-governance. Effective facts sharing complements performance, allows choice-making, and fosters innovation, contributing to sustainable financial and social increase. However, it also offers substantial safety worrying conditions, which include cyberattacks, unauthorized get proper of access to, and privateness breaches. These dangers create hesitancy among businesses and people to exchange facts, negatively impacting digital collaboration and the improvement of intelligent structures. Traditional protection solutions, consisting of encryption, firewalls, and get right of entry to manage structures, rely on centralized models controlled by using a unmarried authority[1]. those systems are often at risk of cyber threats, as relevant databases can be hacked or manipulated, foremost to facts breaches and unauthorized adjustments. This highlights the urgent want for a secure and decentralized technique to protect facts in the path of sharing processes. Blockchain technology has emerged as an revolutionary answer in this region, offering a decentralized, apparent, and tamper-evidence

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machine that enhances believe in records-sharing environments. By making use of allocated ledgers, robust encryption, and clever contracts, blockchain guarantees records safety on the same time as retaining privateness and get admission to control. This technology presents key blessings collectively with immutability, decentralized authentication, and traceability, making it a promising device to address information protection annoying conditions.

To examine the function of blockchain era in improving consistent records sharing, thru exploring present safety demanding conditions and demonstrating how blockchain can feature a strong answer. The study discusses the advantages and obstacles of blockchain, alongside aspect real-global programs that showcase its effectiveness in diverse records-sharing environments. Additionally, it examines the restrictions to huge blockchain adoption and offers future tips for improving its implementation throughout industries.

2. What is Blockchain Technology and Its Core Concepts?

Blockchain is a distributed ledger technology (DLT) that permits the consistent and immutable recording of transactions throughout a decentralized community of pc systems, doing away with the want for a government. This generation is based on robust encryption to defend facts, storing information in interconnected blocks that form a virtual chain, preventing tampering and making sure transparency. Key principles of blockchain encompass decentralization, in which information is shipped during multiple nodes, and the dispensed ledger, allowing contributors to access a shared transaction record. Immutability guarantees that once statistics is recorded, it cannot be altered, at the identical time as cryptographic hashing enhances protection by means of manner of encoding information uniquely. Additionally, smart contracts automate agreements, executing predefined situations with out intermediaries. Blockchain continues safety and receive as genuine with via consensus mechanisms, together with Proof of Work (PoW) and Proof of Stake (PoS), which validate transactions earlier than along with them to the chain. In statistics sharing, blockchain complements transparency, safety, traceability, and privateness by controlling get right of entry to permissions[2]. demanding situations live, inclusive of scalability problems that slow down operations, integration troubles with conventional systems, and the want for clean felony hints to guide huge adoption. Despite those hurdles, blockchain is a transformative solution for securing and sharing statistics, supplying a promising destiny in industries collectively with finance, healthcare, and supply chain control.

3. Literature review

Blockchain era faces numerous demanding situations that avoid its first-rate adoption. One of the number one issues is the shortage of empirical research, as many research on blockchain implementation lack practical and experimental analysis. Additionally, many studies be afflicted by using small pattern sizes and commonly awareness on IT professionals, making the findings hard to generalize throughout one-of-a-kind sectors. Another primary task is the absence of actual-global case research, as many research papers lack realistic examples demonstrating how blockchain is executed in fields along with international exchange and deliver chains. Furthermore, a few research have a constrained scope, focusing handiest on unique programs along with virtual entrepreneurship or sustainability, which prevents a complete analysis of the generation's full capability. Lastly, there are enterprise-specific limitations, where studies is confined to specific industries with out exploring blockchain's integration across severa sectors, making it tough to understand broader adoption traumatic conditions. Given those limitations, there is a easy want for more massive and whole research, in conjunction with real-global

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experiments and case research, to make certain the a hit implementation of blockchain generation across specific industries.

Table 1. Literature review Blockchain Technology

Reference	Analysis	Weaknesses	Critical Analysis	Conclusion	Suggested Improvements
[1]	Blockchain enhances logistics efficiency, resilience, and transparency. Uses empirical data from companies.	Limited empirical research on blockchain adoption in logistics. Early-stage adoption in SCM.	The study effectively combines Fit-Viability and Task-Technology Fit theories, but lacks case study validations.	Blockchain can significantly improve logistics but requires more empirical testing.	Expand the dataset, include case studies, and explore real-world implementations.
[2]	Finds that innovativeness, awareness, and social pressure positively affect blockchain acceptance, while security and privacy concerns hinder adoption.	Small sample size and focus on IT professionals limit generalizability.	Provides key insights into adoption drivers but overlooks broader industry perspectives.	Blockchain adoption is influenced by psychological and social factors, requiring better security assurances.	Increase sample size and include industry-wide perspectives.
[3]	Identifies five key applications: Trade Documents, Trade Finance, Real-Time Information Sharing, Provenance, and Sustainable GVC.	Lacks empirical case studies and real-world implementation insights.	Highlights barriers to adoption but does not provide practical solutions.	Blockchain has strong potential in trade but requires integration with complementary technologies.	Conduct empirical studies and include real-world case studies.
[4]	Finds strong correlation between AI awareness and blockchain adoption for sustainability.	Limited scope, only examines digital entrepreneurs, excludes broader industry implications.	Shows potential for blockchain in SDGs but lacks comprehensive policy recommendations.	Blockchain is useful for sustainability but needs structured policy frameworks.	Expand study to include policymakers and larger business sectors.
[5]	Finds blockchain enhances transparency, traceability, and risk reduction in supply chains.	Study limited to specific industries; does not consider cross-industry implications.	Demonstrates blockchain's resilience benefits but lacks implementation challenges discussion.	Blockchain improves supply chain resilience but adoption remains challenging.	Include cross-industry analysis and real-world adoption barriers.
[6]	Finds blockchain enhances transparency and efficiency in carbon markets.	Limited to theoretical frameworks; lacks empirical validation.	Shows potential for blockchain in carbon trading but lacks practical pilot projects.	Blockchain can enhance carbon markets but needs real-world validation.	Conduct pilot projects and gather empirical data.
[7]	Finds blockchain improves process efficiency, security, and eliminates intermediaries.	Study is simulation-based; lacks real-world deployment	Highlights performance benefits but needs actual market testing.	Blockchain enhances stock trading efficiency but requires further validation.	Implement real-world trials in financial markets.

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		validation.			
[8]	Finds investors show higher blockchain transparency perception and greater trust in cryptocurrencies.	Lacks deep policy implications and focuses mostly on psychological aspects.	Interesting psychographic insights but does not explore adoption barriers extensively.	Blockchain investors exhibit technopian views but may experience existential isolation.	Include policy recommendations and adoption strategies.
[9]	Finds blockchain improves transparency, automation, and contract management.	Focuses on agri-food supply chains; lacks broader sector analysis.	Shows blockchain enhances supply chain trust but lacks empirical depth.	Blockchain positively impacts supply chains but adoption challenges remain.	Expand study to other supply chain industries.
[10]	Finds blockchain improves audit efficiency, security, and transparency.	Limited focus on power grids; lacks broader energy sector analysis.	Demonstrates benefits in audit processes but lacks adoption feasibility discussion.	Blockchain enhances audit efficiency but requires feasibility assessment.	Expand to other energy sectors and assess cost-effectiveness.
[11]	Uses smart contracts to enforce coordination, ensuring decentralized interactions among REST services.	Lacks real-world implementation beyond simulated environments.	Effectively applies blockchain for decentralized service coordination but faces adoption challenges.	RESTChain improves automation and security in service choreographies but requires practical validation.	Expand real-world deployments and assess scalability in large-scale systems.
[12]	Uses account abstraction and smart contracts to enable autonomous IoT transactions.	Security risks in decentralized IoT authentication remain unaddressed.	Innovative approach but lacks a clear security evaluation.	Gasless transactions improve IoT-blockchain integration but require stronger security mechanisms.	Conduct extensive security audits and pilot real-world deployments.
[13]	Finds blockchain enables better tracking of agricultural products, reducing fraud and inefficiencies.	High initial adoption cost limits small farmers' participation.	Strong theoretical model but lacks widespread adoption strategies.	Blockchain can improve agriculture transparency but requires more adoption incentives.	Develop government incentives and pilot projects to encourage adoption.
[14]	Finds blockchain reduces accounting fraud and improves efficiency but remains underutilized.	Focuses on literature analysis without empirical validation.	Provides valuable insights but lacks real-world case studies.	Blockchain can transform accounting but requires industry-wide implementation.	Conduct empirical studies on blockchain applications in real accounting environments.
[15]	Uses smart contracts and PBFT consensus for reliable vote processing.	Scalability and resistance to cyber-attacks remain concerns.	Promising system but lacks large-scale testing under real-world conditions.	Blockchain improves voting security but requires further resilience testing.	Test system in national elections and enhance cybersecurity measures.
[16]	Identifies adoption barriers and proposes ISM-DEMATEL analysis to address them.	Does not propose direct blockchain implementation strategies.	Identifies key barriers but lacks detailed mitigation plans.	Blockchain can aid sustainable construction but adoption barriers must be addressed.	Develop structured policies and pilot real-world implementation projects.

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[17]	Finds blockchain improves transparency in valuation processes.	Limited testing in real estate markets outside Nigeria.	Promising approach but requires wider validation.	Blockchain can improve valuation objectivity but adoption remains a challenge.	Expand study to other property markets and assess adoption challenges.
[18]	Uses revenue-cost sharing contracts to align incentives.	Blockchain cost threshold limits feasibility for smaller farms.	Identifies benefits but does not address implementation challenges.	Blockchain improves supply chain transparency but requires cost-effective solutions.	Develop cost-reducing mechanisms for blockchain adoption in farming.
[19]	Finds adoption depends on diffusion rates among enterprises.	Lacks empirical validation beyond model simulations.	Innovative modeling approach but requires real-world testing.	Blockchain can enhance financial supply chains but adoption barriers persist.	Conduct empirical studies on financial institutions adopting blockchain.
[20]	Finds blockchain can increase transparency but also risks supplier intrusion.	Conflicts between manufacturers and suppliers not fully resolved.	Highlights risks but lacks mitigation strategies.	Blockchain can enhance transparency but also disrupt supply chain dynamics.	Develop regulatory frameworks to prevent supplier encroachment issues.
[21]	Finds blockchain can enhance trust, transparency, and efficiency in natural resource management.	Study is qualitative with limited real-world implementation testing.	Demonstrates blockchain's benefits but lacks quantitative validation.	Blockchain is useful for sustainable resource management but requires pilot projects.	Develop real-world trials and quantify blockchain's effectiveness in mining operations.
[22]	Identifies privacy concerns, regulatory barriers, and education gaps as adoption barriers.	Limited sample size; lacks large-scale empirical validation.	Provides initial insights but does not assess adoption metrics quantitatively.	Blockchain can improve transparency in advertising but needs regulatory support.	Expand study to industry-wide adoption and assess real-world implementations.
[23]	Finds blockchain enhances supplier evaluation and decision-making under uncertainty.	Simulation-based; lacks real-world supply chain testing.	Promising methodology but requires empirical validation.	Blockchain improves supply chain efficiency but requires real-world testing.	Conduct industry-wide pilot studies to validate the model.
[24]	Finds blockchain enhances security and transparency in copyright protection.	Lacks real-world testing; potential scalability issues.	Promising model but lacks implementation strategies.	Blockchain improves copyright protection but requires scalable solutions.	Expand real-world applications and evaluate performance at scale.
[25]	Finds blockchain improves data integrity but introduces computational overhead.	Scalability and computational cost remain concerns.	Blockchain enhances big data security but needs optimization for efficiency.	Blockchain benefits big data but requires computational optimizations.	Develop lightweight blockchain frameworks for big data analytics.
[26]	Finds blockchain can enhance supply chain transparency but privacy concerns hinder adoption.	Lacks industry-wide implementation examples.	Addresses privacy issues but does not offer regulatory solutions.	Blockchain improves supply chains but requires privacy-preserving mechanisms.	Develop blockchain solutions integrating privacy-enhancing technologies.
[27]	Finds blockchain	Adoption	Promising approach	Blockchain can	Develop cost-

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	enhances transparency and traceability in seed certification.	barriers for small-scale farmers remain unaddressed.	but lacks cost-effective adoption strategies.	enhance agricultural transparency but affordability is key.	effective blockchain adoption frameworks for small farmers.
[28]	Finds high initial investment and lack of digital skills are key barriers.	Limited to a single industry; lacks broader supply chain perspectives.	Identifies key barriers but does not offer comprehensive mitigation strategies.	Blockchain can enhance supply chain sustainability but requires industry-wide strategies.	Develop financial incentives and training programs for manufacturers.
[29]	Finds blockchain can enhance carbon reduction strategies but lacks real-world testing.	Theoretical model; lacks large-scale implementation examples.	Addresses key challenges but does not evaluate cost-effectiveness.	Blockchain can aid carbon reduction but requires pilot implementations.	Test real-world applications and evaluate economic feasibility.
[30]	Finds blockchain enhances data standardization and security in water management.	Lacks empirical real-world implementation outside simulations.	Strong theoretical model but practical application challenges remain.	Blockchain can improve water data security but requires field deployment testing.	Pilot real-world studies and integrate with existing water networks.
[31]	Finds blockchain-based ecosystems improve data sharing and trust management.	Requires more scalability analysis in large enterprises.	Conceptually strong but lacks case studies outside agriculture.	Blockchain enhances information ecosystems but requires enterprise adoption strategies.	Conduct cross-industry case studies and optimize scalability.
[32]	Finds blockchain improves security and transparency in geospatial applications.	Legal and interoperability challenges remain unaddressed.	Comprehensive review but lacks legal framework integration.	Blockchain is promising for geospatial data but requires regulatory compliance.	Develop legal guidelines and test real-world geospatial applications.
[33]	Finds MetaTune improves blockchain efficiency in varying network environments.	Lacks real-world validation beyond controlled simulations.	Strong performance improvement but requires on-chain deployment testing.	MetaTune optimizes blockchain performance but needs real-world evaluation.	Test AI-based tuning in operational blockchain systems.
[34]	Finds blockchain improves security, resource sharing, and book lending transparency.	Scalability concerns in large library networks remain.	Addresses transparency issues but requires integration with existing systems.	Blockchain can improve smart libraries but requires interoperability strategies.	Develop standards for integration with existing library software.
[35]	Finds blockchain improves security and attack detection in healthcare data flows.	Computational costs and latency remain concerns.	Enhances security but increases processing complexity.	Blockchain strengthens healthcare security but requires efficiency optimizations.	Develop lightweight blockchain models for real-time healthcare applications.
[36]	Finds blockchain enhances fraud detection and regulatory compliance.	Simulation-based study; lacks real-world deployment validation.	Strong security model but needs implementation in financial institutions.	Blockchain improves financial security but requires adoption strategies.	Test system in real banking environments and regulatory compliance settings.
[37]	Finds blockchain improves energy	Limited adoption in rural	Promising model but adoption in rural	Blockchain enhances smart	Develop cost-effective solutions

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	efficiency and remote access control.	areas due to infrastructure challenges.	regions remains difficult.	homes but needs infrastructure improvements.	for rural smart home implementation.
[38]	Finds blockchain improves transparency and sustainability in supply chain management.	High costs and lack of standardization hinder adoption.	Addresses key sustainability challenges but requires standardized implementation.	Blockchain can support green supply chains but requires cost-effective models.	Develop blockchain-based sustainability standards and cost models.
[39]	Finds blockchain enhances interoperability and security in patient data exchange.	Complexity of implementation across different healthcare systems.	Promising framework but requires industry-wide adoption efforts.	Blockchain improves health data security but needs standardized frameworks.	Develop regulatory compliance guidelines for blockchain health data sharing.
[40]	Finds Hyperledger improves data security and process transparency in higher education.	Limited real-world adoption and scalability testing.	Strong theoretical model but lacks institutional implementation evidence.	Blockchain can enhance education management but requires pilot projects.	Test Hyperledger adoption in universities and assess scalability.
[41]	Finds blockchain can improve online tax collection but faces regulatory challenges.	Regulatory barriers and lack of technical readiness hinder adoption.	Strong policy implications but requires better regulatory alignment.	Blockchain can improve tax compliance but requires legislative backing.	Develop legal frameworks and test pilot projects in tax systems.
[42]	Finds blockchain enhances security and efficiency in tourism data processing.	Limited real-world application and case study analysis.	Innovative model but requires empirical validation.	Blockchain can improve tourism management but needs pilot testing.	Deploy pilot projects in tourism regions and assess scalability.
[43]	Finds structured governance improves blockchain adoption in enterprises.	Lacks testing across different blockchain ecosystems.	Strong framework but requires industry-wide adoption strategies.	Blockchain governance improves adoption but needs standardization.	Test governance models across different industries.
[44]	Finds blockchain enhances innovation in enterprises with high tech adoption.	Focuses on Chinese companies, limiting global applicability.	Empirical study but lacks cross-industry validation.	Blockchain fosters innovation but requires broader industry analysis.	Expand study to global enterprises for broader insights.
[45]	Finds blockchain improves supply chain efficiency and reduces fraud.	Limited testing in real-world food distribution chains.	Addresses transparency issues but lacks implementation case studies.	Blockchain improves food supply chains but needs industry-wide testing.	Test hybrid blockchain models in large-scale food networks.
[46]	Finds blockchain enhances transparency, sustainability, and supply chain efficiency.	Lacks empirical case studies beyond literature review.	Highlights sustainability benefits but needs real-world evidence.	Blockchain can improve food security but requires implementation studies.	Conduct field trials to validate blockchain's impact on food security.
[47]	Finds blockchain can enhance trust in food product information.	High implementation costs limit small farmers' adoption.	Addresses trust issues but lacks feasibility studies.	Blockchain can improve agricultural transparency but needs cost-effective models.	Develop financial models to reduce blockchain adoption costs for farmers.
[48]	Finds blockchain can improve ESG	Regulatory adoption and	Strong potential for ESG but requires	Blockchain can enhance ESG	Develop standardized

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	reporting integrity and reduce greenwashing.	standardization remain unclear.	regulatory backing.	reporting but requires policy alignment.	blockchain frameworks for ESG disclosures.
[49]	Finds blockchain improves data security, transparency, and authentication in teaching management.	Limited to language teaching; lacks application in broader education fields.	Strong security features but requires expansion beyond language education.	Blockchain enhances education security but needs broader adoption in the education sector.	Expand to other education management systems and evaluate large-scale implementation.
[50]	Finds blockchain improves real-time monitoring and traffic management, reducing congestion.	Lacks nationwide implementation case studies.	Innovative model but requires large-scale ITS deployment.	Blockchain enhances ITS but needs real-world policy and infrastructure support.	Pilot blockchain-integrated ITS projects across major cities.
[51]	Finds knowledge, persuasion, and decision stages influence blockchain adoption.	Lacks empirical case studies from industries actively using blockchain.	Theoretical model is strong but lacks industry-specific validation.	Blockchain adoption follows DOI principles but needs real-world case studies.	Apply the DOI model to various industries and assess adoption challenges.
[52]	Finds blockchain improves UAV communication security but increases computational overhead.	Processing latency due to blockchain complexity.	Enhances security but computational efficiency is a concern.	Blockchain secures UAV communication but needs lightweight implementation.	Develop low-latency blockchain frameworks for UAV applications.
[53]	Finds blockchain strengthens trust, transparency, and coordination in supply chains.	Lacks real-world adoption cases beyond Chinese construction firms.	Conceptually strong but requires global validation.	Blockchain enhances construction supply chains but requires broader industry adoption.	Expand study to global construction markets and evaluate industry-wide adoption.
[54]	Finds blockchain reduces intermediaries and enhances food traceability.	Limited scalability beyond the Bangladesh context.	Strong practical application but needs expansion to other food supply chains.	Blockchain improves food traceability but requires multi-regional scalability.	Test blockchain food traceability models in multiple regions.
[55]	Finds regulatory gaps, technical challenges, and cost as major adoption barriers.	Lacks real-world case studies on logistics companies adopting blockchain.	Identifies barriers but does not propose practical solutions.	Blockchain adoption faces multiple challenges in logistics.	Develop policy frameworks and pilot logistics blockchain projects.
[56]	Finds blockchain enhances transparency, accountability, and sustainability in emerging economies.	Lacks empirical validation in developed economies.	Strong framework for sustainability but requires broader industry application.	Blockchain supports sustainability management but needs global case studies.	Expand study to developed economies and evaluate different industries.
[57]	Finds blockchain strengthens data security but increases access latency.	High computational overhead for large-scale IoT networks.	Secure access control but requires efficiency optimizations.	Blockchain enhances IoT security but needs performance improvements.	Develop optimized access control models with reduced computational costs.

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[58]	Finds blockchain enhances security, adaptability, and scalability in smart grids.	Lacks real-world implementation at national grid levels.	Strong security model but requires deployment in smart grid infrastructures.	Blockchain secures smart grids but requires nationwide testing.	Pilot blockchain-based learning models in smart grid environments.
[59]	Finds blockchain reduces fraud and improves efficiency in supply chains, particularly in ports.	Lacks empirical real-world implementation studies.	Strong potential for logistics but requires large-scale deployment testing.	Blockchain can optimize logistics, but practical implementations are needed.	Conduct real-world pilot studies to measure actual cost savings and efficiency gains.
[60]	Finds perceived ease of use and top management support as key adoption factors.	Limited to Saudi Arabia; lacks global comparisons.	Valid TAM model application but requires broader industry-wide validation.	Blockchain adoption in construction depends on management and ease of use.	Expand study to other regions and industries for comparative insights.
[61]	Finds blockchain enhances transparency and increases organic food purchase intent.	Lacks implementation case studies in diverse markets.	Strong theoretical support but needs empirical validation.	Blockchain can build consumer trust in food safety but needs wider industry adoption.	Test blockchain food traceability systems in multiple regions.
[62]	Finds blockchain knowledge is a key moderator in adoption behavior.	Limited consumer data from one region.	Highlights blockchain's role in food safety but requires cross-market validation.	Blockchain can improve food traceability but requires global adoption.	Expand consumer sample size across multiple demographics.
[63]	Finds blockchain improves patient data security and insurance claims processing.	Implementation costs and regulatory challenges.	Strong security benefits but adoption barriers remain.	Blockchain can transform healthcare, but compliance issues persist.	Develop regulatory frameworks to facilitate blockchain integration.
[64]	Finds blockchain improves traceability and reduces supply chain fraud.	High implementation costs and resistance from manufacturers.	Addresses transparency but adoption costs are high.	Blockchain can improve semiconductor supply chains but needs cost-effective models.	Develop cost-sharing models to encourage adoption.
[65]	Finds blockchain is widely applicable but faces scalability and regulatory issues.	Lacks in-depth discussion of emerging blockchain frameworks.	Broad overview but needs specific implementation case studies.	Blockchain is a transformative technology but still evolving.	Analyze real-world blockchain applications in greater detail.
[66]	Finds blockchain reduces fraud risks and improves transaction security.	Scalability issues for smaller SMEs.	Strong security benefits but high adoption costs for SMEs.	Blockchain can secure SME e-commerce but needs cost-effective solutions.	Develop low-cost blockchain models tailored for SMEs.
[67]	Finds blockchain reduces latency in medical data exchange.	Requires high computational resources.	Enhances security but efficiency concerns persist.	Blockchain can improve medical IoT security but needs optimization.	Develop lightweight blockchain frameworks for IoT.
[68]	Finds blockchain reduces fraud in small-scale markets.	Limited to QR-code and barcode-based solutions.	Addresses counterfeit issues but needs more integration with AI.	Blockchain can secure product authenticity but needs expanded tech integration.	Integrate blockchain with AI for advanced fraud detection.

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[69]	Finds that institutional ownership reduces cash holdings, while managerial ownership favors it.	Limited focus on non-Chinese blockchain firms; lacks global applicability.	Offers financial governance insights but needs cross-country validation.	Blockchain firms' governance impacts financial decisions; global validation needed.	Expand study to blockchain firms outside China for broader applicability.
[70]	Identifies key themes like decentralized energy trading and sustainable urban grids.	Does not provide practical implementation case studies.	Solid theoretical insights but needs more real-world applications.	Blockchain has vast renewable energy potential but lacks empirical validation.	Conduct case studies on blockchain-enabled renewable energy projects.
[71]	Finds that EMT improves security and reduces data verification time.	Application is limited to healthcare data privacy.	Strong innovation but lacks generalizability beyond healthcare.	Blockchain enhances healthcare privacy but needs broader applications.	Adapt EMT to finance and e-commerce for broader usage.
[72]	Finds that smart contracts automate transactions and improve energy efficiency.	Lacks large-scale real-world trials.	Promising model but needs testing in real-world energy markets.	Blockchain can revolutionize microgrids but requires large-scale adoption.	Implement pilot projects to validate efficiency and scalability.
[73]	Finds blockchain improves transaction speed and accuracy in carbon markets.	No large-scale deployment in global carbon trading schemes.	Strong conceptual framework but needs real-world testing.	Blockchain can optimize carbon trading but requires policy adoption.	Conduct cross-border carbon trading experiments with blockchain.
[74]	Finds sustainability-driven blockchain firms are deeply embedded in local business networks.	Limited to US-based companies; lacks international comparisons.	Useful for policy but needs global perspective.	Blockchain fosters sustainability, but global insights are needed.	Expand study to international blockchain ecosystems.
[75]	Finds blockchain enhances computational security but introduces latency.	Trade-off between security and computational speed.	Secure model but efficiency challenges remain.	Blockchain improves ML security but needs speed optimization.	Optimize blockchain protocols for low-latency computations.
[76]	Finds blockchain enhances environmental data transparency and governance efficiency.	Focused only on Qinghai Province, China.	Strong model but lacks multi-region implementation.	Blockchain enhances ecological governance but needs global testing.	Pilot blockchain-driven ecological governance projects in multiple regions.
[77]	Finds blockchain reduces product uncertainty by enhancing transparency.	Relies on consumer behavior studies, lacks empirical blockchain case studies.	Valid consumer insights but needs more technology-based studies.	Blockchain builds consumer trust, but its practical adoption needs validation.	Develop blockchain-based consumer apps for real-world sustainability verification.
[78]	Finds key research trends and identifies future blockchain challenges.	Broad scope lacks deep industry-specific analysis.	Good thematic overview but lacks sector-specific insights.	Blockchain research is expanding, but industry-specific gaps remain.	Focus future studies on blockchain's impact in specific industries.
[79]	Finds that trigonometric	Limited to Bitcoin	Novel statistical model but needs real-	Blockchain transaction times	Test model on multiple blockchain

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	probability models improve accuracy in transaction time prediction.	blockchain; lacks application to other blockchain systems.	world validation.	can be better predicted with statistical models.	platforms for broader applicability.
[80]	Finds that hybrid encryption enhances security and authentication in HealthCare 4.0.	Complex framework requires high computational power.	Improves security but computational efficiency remains an issue.	Blockchain strengthens healthcare data security but requires optimization.	Develop lightweight blockchain algorithms for real-time medical applications.
[81]	Finds blockchain reduces fraud and increases traceability in agricultural supply chains.	Limited pilot implementation; requires larger deployment.	Strong potential but needs scalability testing.	Blockchain can improve agricultural supply chains but needs real-world trials.	Expand trials to multiple agricultural regions and industries.
[82]	Finds smart contracts reduce paperwork and fraud in bunkering operations.	Limited to a single case study; lacks global adoption analysis.	Highlights efficiency gains but broader adoption remains uncertain.	Blockchain can streamline marine bunkering but requires widespread industry support.	Conduct global case studies to assess blockchain's impact on bunkering.
[83]	Finds PoS and PBFT improve scalability but introduce trade-offs in security and decentralization.	Lacks empirical validation of newer consensus mechanisms.	Good theoretical review but lacks practical implementation insights.	Scalable consensus algorithms are evolving but need real-world testing.	Analyze practical deployment of newer consensus mechanisms in live blockchain networks.
[84]	Finds blockchain enhances data integrity but increases computational overhead.	Scalability issues in real-time time-series data processing.	Promising for secure data classification but needs optimization.	Blockchain secures time-series data but requires efficiency improvements.	Optimize blockchain structures for real-time classification tasks.
[85]	Finds blockchain improves transparency but faces adoption barriers in developing countries.	Limited sample size; lacks comparative studies with developed markets.	Addresses barriers to adoption but needs more case studies.	Blockchain can enhance supply chains but needs supportive policies.	Conduct cross-country studies to compare blockchain adoption rates.
[86]	Finds blockchain increases procurement efficiency and supplier transparency.	Limited discussion on blockchain's impact on small enterprises.	Strong theoretical model but needs practical validation.	Blockchain optimizes procurement but needs broader industry adoption.	Implement blockchain procurement models in diverse industries for validation.
[87]	Finds blockchain improves traceability and reduces contamination risks.	Limited to halal food supply chains; lacks broader food industry applications.	Enhances food safety but needs industry-wide adoption.	Blockchain can improve halal food safety but requires policy support.	Expand study to other food industries and regulatory frameworks.
[88]	Finds blockchain reduces costs and enhances trust in tourism services.	Adoption remains limited to a few early adopters.	Strong business case but requires industry-wide acceptance.	Blockchain can transform tourism but adoption barriers persist.	Encourage collaboration between tourism enterprises for blockchain integration.
[89]	Knowledge	The study	Challenges in	Blockchain provides	Enhances

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	Transaction Protection via Blockchain	focuses on using blockchain technology to protect knowledge transactions in open innovation communities.	implementation include scalability, costs, and regulatory compliance.	high security but may face integration issues with existing systems.	knowledge transaction security but requires effective risk management.
[90]	IoT Data Sharing via Blockchain & Federated Learning	Proposes a multi-layered system to enhance IoT data sharing using federated learning.	Issues include uneven data distribution, security risks, and high communication costs.	The system improves model accuracy but heavily relies on data distribution among devices.	Can enhance data-sharing accuracy but must address connectivity and cost issues.
[91]	AI & Blockchain Adoption in the Maritime Industry	Analyzes barriers to technology adoption in the shipping sector using the Fuzzy DEMATEL approach.	Challenges include cybersecurity, system interoperability, and lack of technical expertise.	The industry requires tailored policies to improve adoption and mitigate associated risks.	Technology can enhance efficiency but requires suitable policies and government support.
[92]	Warehouse Management via Blockchain	Discusses how blockchain technology improves warehouse efficiency and transparency.	Challenges include technical barriers, infrastructure changes, and legal concerns.	Technology enhances real-time inventory tracking but requires significant initial investment.	Can improve operations but needs a gradual and well-planned adoption.
[93]	Medical Blockchain Applications in China	Explores the use of blockchain in medical applications, focusing on data security and intellectual property protection.	Regulatory complexities, integration with existing medical systems, and high implementation costs.	Medical blockchain enhances data integrity but requires strong compliance measures and technological advancements.	Can significantly enhance medical data security but requires regulatory approval and institutional support.

4. Proposed Solutions to Blockchain Challenges

To cope with the demanding situations hindering the adoption of blockchain era, numerous measures have to be taken to beautify its information and decorate its packages during severa sectors. Firstly, it is crucial to make bigger datasets and consist of real-international case research, as many contemporary research lack practical evaluation. Including whole facts and real-global examples can offer deeper insights into how blockchain is applied in commercial and commercial enterprise environments. Additionally, developing the pattern length in experimental research is essential, as many contemporary studies consciousness most effective on IT experts. Expanding the research to encompass members from one-of-a-type sectors which include finance, healthcare, and exchange will offer a broader angle on blockchain's impact. Moreover, there can be a strong need for carrying out empirical studies supported with the resource of real-worldwide statistics, as many current studies rely upon theoretical assumptions without realistic validation. Implementing actual-life experiments and reading their outcomes will help establish blockchain's effectiveness and protection.

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Broadening research scope to encompass policymakers and most important businesses is vital, as regulatory compliance performs a important feature within the massive adoption of blockchain. Engaging regulators and choice-makers can facilitate the improvement of felony frameworks that help blockchain implementation interior easy regulatory environments. To maximize blockchain's ability, studies should additionally examine its integration in the course of more than one industries in preference to focusing on restricted programs. Exploring blockchain's use in exclusive fields will find out new demanding situations and possibilities which have no longer started to be absolutely examined. By enforcing these whole answers, blockchain technology can gain extra be given as genuine with and broader adoption, ultimately contributing to the improvement of extra consistent and obvious systems for data sharing and virtual transactions across severa industries.

5. Strengths of Blockchain Technology

Blockchain era offers numerous strengths that make it a perfect solution for securing statistics sharing and improving transaction efficiency. One of its number one advantages is its excessive protection, as it makes use of advanced encryption algorithms and a decentralized structure to guard statistics from tampering and cyberattacks. Additionally, transparency and credibility are key strengths, as blockchain presents a tamper-evidence ledger that lets in all stakeholders to affirm transactions without the want for intermediaries, lowering fraud and increasing trust. The generation moreover complements identification control and authentication, allowing steady and automated verification thru smart contracts, which gets rid of the hazard of identity theft. Moreover, charge performance is some extraordinary important advantage, as blockchain reduces operational charges by way of manner of minimizing reliance on 1/three parties, rushing up transactions[94] and putting off guide processing. Furthermore, blockchain's integration with superb generation, together with synthetic intelligence (AI) and the Internet of Things (IoT), permits for advanced statistics analytics, automation, and stepped forward safety across more than one industries, which incorporates finance, healthcare, and deliver chain control.

6. Weaknesses of Blockchain Technology

Despite its many blessings, blockchain generation faces severa demanding situations that save you its extensive adoption. One of the most giant issues is scalability, as transaction validation may be sluggish and beneficial useful resource-massive, limiting the network's capability to deal with massive volumes of transactions successfully. Additionally, blockchain structures that rely upon proof-of-paintings (PoW) consensus mechanisms eat huge quantities of strength, leading to excessive operational costs and environmental issues. Another primary project is regulatory and legal uncertainty, as many countries although lack clear frameworks for blockchain governance, making compliance with information protection felony tips at the side of GDPR complicated. Furthermore, integration with conventional systems stays difficult, as many businesses rely upon centralized infrastructures that are not with out issues adaptable to blockchain's decentralized nature. Privacy troubles moreover upward push up because of the technology's inherent transparency,[95] which may moreover divulge sensitive facts besides personal or hybrid blockchain solutions are implemented. Finally, excessive implementation and improvement costs pose a barrier, as blockchain adoption requires extensive investments in infrastructure, specialised talents, and training, making it specially hard for small and medium-sized businesses.

7. Future Trends of Blockchain Technology:

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Findings from the research recommend that blockchain generation will maintain to comply as a essential trouble in the course of diverse industries, with a focal point on improving overall performance, improving safety, and increasing its packages. Firstly, blockchain is anticipated to play a critical function in deliver chains, wherein it is going to be leveraged to enhance transparency, music merchandise, and reduce operational fees through automation and clever agreement generation. Additionally, the adoption of blockchain in worldwide alternate is predicted to boom, mainly in digitizing alternate files, facilitating flow-border transactions, and minimizing fraud and corruption dangers.Research advise that sustainability can be a key problem in blockchain development, with efforts to make the era greater electricity-inexperienced, contributing to international environmental desires. The destiny of blockchain can even see enhancements in hazard management and data protection, with new fashions being advanced to reinforce safety toward cyber threats and make certain more regulatory compliance. Despite those promising potentialities, challenges along side regulatory alignment, tool integration, and scalability enhancements must be addressed to optimize blockchain adoption and effectiveness.

8. Conclusion

Research findings suggest that blockchain can drastically enhance overall performance and transparency throughout diverse sectors, specifically in logistics, international alternate, and sustainability. Studies highlight that blockchain adoption is stimulated with the useful resource of mental, social, and technological elements, emphasizing the want to elevate attention among groups and clients approximately its advantages and implementation mechanisms. Blockchain also has sturdy functionality in global exchange, mainly in streamlining business transactions and reducing risks related to fraud and counterfeiting, although similarly research is needed to evaluate its actual-worldwide applications. In phrases of sustainability, findings advocate that blockchain can be an effective device for helping sustainable development desires, but it although faces operational efficiency and device integration disturbing conditions. Additionally, its function in enhancing supply chain resilience is promising, because it improves transparency and traceability, yet its adoption stays restricted because of scalability and implementation boundaries.

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