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The Economic Impact of Blockchain Technology in the Digital Age: A Conceptual and Strategic Analysis

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Abstract— Blockchain technology has emerged as one of the most transformative innovations of the digital economy, extending far beyond cryptocurrencies into sectors such as finance, healthcare, logistics, governance, and intelligent automation. This study critically examines the role of blockchain technology in enhancing global economic growth through decentralization, transparency, cybersecurity, smart contracts, and digital trust mechanisms. Drawing upon contemporary literature and emerging industrial applications, the paper explores how blockchain contributes to economic resilience, operational efficiency, supply chain optimization, decentralized finance (DeFi), central bank digital currencies (CBDCs), and AI-integrated digital ecosystems. The study adopts a conceptual and analytical approach to evaluate blockchain's macroeconomic implications and institutional challenges in the context of Industry 4.0. Findings suggest that blockchain has the potential to reduce transaction costs, enhance cross-border economic integration, improve governance transparency, and facilitate sustainable digital transformation. However, regulatory uncertainty, scalability limitations, cybersecurity concerns, and energy consumption remain significant barriers to global adoption. The paper contributes to the literature by proposing an integrated framework linking blockchain innovation with economic sustainability, digital governance, and technological resilience. Policy implications and future research directions are also discussed.

Keywords: Smart Contracts, Decentralized Finance (DeFi) , Digital Economy

I. INTRODUCTION

The rapid expansion of digital technologies has fundamentally transformed global economic systems, institutional governance, and industrial operations. Emerging technologies such as artificial intelligence (AI), the Internet of Things (IoT), cloud computing, and blockchain are reshaping how organizations create value, exchange information, and establish trust in decentralized environments. Among these innovations, blockchain technology has gained considerable scholarly and industrial

attention due to its potential to enhance transparency, reduce transaction costs, strengthen cybersecurity, and facilitate decentralized economic coordination.

The global economy is undergoing a profound digital transformation driven by rapid advancements in emerging technologies such as artificial intelligence (AI), the Internet of Things (IoT), cloud computing, big data analytics, and blockchain technology. Among these innovations, blockchain has attracted considerable scholarly, industrial, and governmental attention due to its potential to fundamentally redefine economic transactions, institutional trust, and decentralized coordination mechanisms. Originally conceptualized as the underlying architecture of Bitcoin by Nakamoto (2008), blockchain technology has evolved far beyond cryptocurrency ecosystems and is increasingly being adopted across sectors including finance, healthcare, logistics, governance, manufacturing, energy, and international trade. Its decentralized and immutable structure enables secure, transparent, and tamper-resistant data management without reliance on centralized intermediaries.

The increasing digitization of economic activities has simultaneously amplified concerns related to cybersecurity, data manipulation, operational inefficiencies, information asymmetry, and institutional distrust. Traditional centralized systems often suffer from vulnerabilities such as single points of failure, lack of transparency, high transaction costs, and limited interoperability among stakeholders. In this context, blockchain technology offers an alternative governance architecture capable of enhancing transparency, traceability, automation, and digital trust across complex economic networks. Through distributed ledger mechanisms and consensus protocols, blockchain enables secure peer-to-peer interactions, real-time verification, and immutable recordkeeping, thereby reducing dependency on intermediaries and enhancing operational efficiency.



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In recent years, the applications of blockchain technology have expanded significantly in response to the growing demand for resilient and decentralized digital infrastructures. Decentralized Finance (DeFi) platforms are transforming conventional financial systems by enabling borderless financial transactions and decentralized lending mechanisms. Similarly, Central Bank Digital Currencies (CBDCs) are being explored by numerous governments to modernize monetary systems and improve financial inclusion. Smart contracts have introduced automated and self-executing transaction frameworks that reduce administrative costs and contractual disputes. Furthermore, blockchain-enabled supply chain systems have enhanced product traceability, fraud prevention, and sustainability monitoring, particularly in global logistics and manufacturing sectors. The integration of blockchain with AI and IoT technologies has also accelerated the emergence of intelligent decentralized ecosystems capable of supporting predictive analytics, autonomous decision-making, and digital governance.

Despite the growing adoption of blockchain technology, the scholarly discourse remains fragmented regarding its comprehensive contribution to global economic transformation. Existing studies predominantly focus on cryptocurrency markets, technical architectures, or isolated industrial applications, while limited research systematically examines blockchain's multidimensional role in fostering economic resilience, sustainable development, institutional transparency, and digital governance within the broader context of Industry 4.0 and the post-pandemic digital economy. Moreover, substantial concerns persist regarding scalability, regulatory uncertainty, energy consumption, cybersecurity risks, interoperability challenges, and governance complexities associated with decentralized systems. These unresolved issues create a critical need for a more integrated conceptual understanding of how blockchain can simultaneously support innovation, economic efficiency, sustainability, and institutional trust in the contemporary global economy.

Accordingly, this study seeks to critically examine the transformative role of blockchain technology in boosting the global economy by analyzing its economic, technological, and institutional implications. The paper aims to explore how blockchain-driven decentralization contributes to financial innovation, operational efficiency, digital governance, supply chain transparency, and sustainable economic development. In addition, the study investigates the opportunities and challenges associated

with emerging blockchain applications such as DeFi, CBDCs, smart contracts, AI-blockchain integration, and cybersecurity frameworks. By synthesizing contemporary literature and industrial developments, the study proposes a conceptual perspective linking blockchain adoption with economic resilience and digital transformation.

The significance of this study lies in its attempt to bridge the gap between technological innovation and macroeconomic transformation through a multidisciplinary analytical framework. Unlike earlier descriptive studies focusing primarily on cryptocurrencies, this paper adopts a broader conceptual orientation by positioning blockchain as a foundational infrastructure for the next generation of digital economies. The study contributes to the existing literature by integrating economic, managerial, technological, and governance dimensions into a unified discussion of blockchain-enabled global transformation.

II. NEED OF THE STUDY

The rapid advancement of blockchain technology has generated significant academic and industrial interest due to its transformative potential across multiple sectors of the global economy. Although prior studies have largely concentrated on cryptocurrencies, digital payments, and decentralized financial systems, comparatively limited attention has been given to the broader economic and institutional implications of blockchain technology in an integrated manner. In particular, there is a lack of comprehensive research examining how blockchain can contribute simultaneously to economic resilience, digital governance, intelligent automation, sustainable supply chain management, and the restructuring of economies in the post-pandemic era.

The increasing dependence on digital infrastructures and data-driven economic systems has intensified concerns regarding cybersecurity, transparency, operational efficiency, and institutional trust. Governments, businesses, and policymakers across the world are actively exploring blockchain-based solutions to address these challenges; however, scholarly understanding of the technology's multidimensional impact remains fragmented. Existing literature often evaluates blockchain applications in isolation, without establishing a unified conceptual framework linking technological innovation with broader economic transformation and sustainable development goals.

Furthermore, despite the growing adoption of blockchain across industries, there is still no clear academic consensus



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regarding its capability to balance transparency, decentralization, security, and regulatory compliance within complex global economic systems. Issues such as scalability limitations, governance uncertainty, interoperability challenges, legal ambiguities, and technological vulnerabilities continue to hinder its large-scale implementation. Therefore, there is a strong need for a systematic and conceptually grounded study that critically examines the role of blockchain technology in enhancing global economic growth while addressing the associated opportunities, risks, and policy implications.

This study is undertaken to bridge these gaps by providing a comprehensive analysis of blockchain technology as an emerging driver of digital economic transformation. The research seeks to develop a broader understanding of blockchain's contribution to sustainable development, institutional efficiency, technological innovation, and economic modernization in the contemporary global context.

III. THEORETICAL FOUNDATIONS OF BLOCKCHAIN TECHNOLOGY AND ECONOMIC TRANSFORMATION

Blockchain technology has emerged as a disruptive innovation capable of transforming traditional economic systems, institutional governance, and digital business models. The theoretical understanding of blockchain is grounded in decentralization theory, transaction cost economics, institutional theory, innovation diffusion theory, and digital transformation frameworks. Collectively, these theoretical perspectives explain how blockchain technology reshapes economic interactions by reducing dependency on centralized authorities, improving transparency, and enhancing trust among stakeholders.

From the perspective of transaction cost economics, blockchain minimizes intermediary involvement, thereby reducing transaction verification costs, contractual uncertainties, and information asymmetry in economic exchanges. Smart contracts further automate transactions and contractual obligations through self-executing protocols, increasing operational efficiency and reducing administrative burdens. Institutional theory also supports blockchain adoption by emphasizing the role of transparent and immutable digital infrastructures in strengthening organizational trust, governance accountability, and regulatory compliance.

Innovation diffusion theory explains the growing adoption of blockchain across industries due to its perceived

advantages in security, traceability, automation, and interoperability. As organizations increasingly pursue digital transformation strategies under Industry 4.0, blockchain is being integrated with artificial intelligence (AI), cloud computing, big data analytics, and the Internet of Things (IoT) to develop intelligent and decentralized economic ecosystems. In this regard, blockchain is no longer viewed solely as the technological foundation of cryptocurrencies but as an institutional infrastructure supporting digital governance, sustainable development, and resilient economic systems.

Contemporary theoretical discourse also positions blockchain within the broader framework of digital economy transformation. Distributed ledger systems facilitate decentralized coordination, real-time information sharing, and secure digital transactions, thereby improving productivity and institutional efficiency. Moreover, blockchain contributes to economic resilience by enabling transparent supply chains, strengthening cybersecurity mechanisms, supporting decentralized financial systems, and reducing systemic vulnerabilities associated with centralized databases.

Recent theoretical studies further suggest that blockchain can enhance sustainable economic development by promoting resource optimization, green finance, digital inclusion, and accountable governance systems. However, scholars also caution that technological scalability, regulatory fragmentation, interoperability challenges, and energy-intensive consensus mechanisms remain major theoretical and practical concerns limiting widespread blockchain implementation.

IV. REVIEW OF CONTEMPORARY LITERATURE

The growing importance of blockchain technology has attracted substantial scholarly attention across the fields of economics, finance, management, information systems, and public governance. Existing literature broadly examines blockchain applications in decentralized finance (DeFi), digital currencies, supply chain management, cybersecurity, healthcare systems, governance mechanisms, and sustainable digital transformation.

Early blockchain literature primarily focused on cryptocurrencies and peer-to-peer digital payment systems. Nakamoto (2008) introduced blockchain as the foundational architecture for Bitcoin, emphasizing decentralization, cryptographic security, and trustless financial transactions. Subsequent studies expanded the



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conceptual understanding of blockchain by exploring distributed ledger structures, consensus mechanisms, and smart contract applications (Zheng et al., 2017).

Recent literature demonstrates a substantial shift from cryptocurrency-centric discussions toward broader economic and institutional applications of blockchain technology. Khan et al. (2021) highlighted the transformative role of smart contracts in automating financial and operational processes across industries. Similarly, Rawat et al. (2020) argued that blockchain improves the reliability and security of smart systems through decentralized verification mechanisms and tamper-resistant databases.

Within the financial sector, decentralized finance (DeFi) has emerged as one of the most influential blockchain-driven innovations. DeFi platforms facilitate lending, borrowing, insurance, and asset trading without centralized intermediaries, thereby improving financial inclusion and transaction efficiency. Vasishtha et al. (2025) observed that DeFi systems have the potential to enhance the accessibility and affordability of financial services, particularly in underbanked economies. However, governance uncertainty, cybersecurity vulnerabilities, and regulatory ambiguity continue to hinder institutional acceptance of decentralized financial ecosystems.

Another major area of contemporary research relates to Central Bank Digital Currencies (CBDCs). Governments and central banks worldwide are increasingly exploring blockchain-enabled digital currencies to modernize payment systems and strengthen monetary governance. Dell'Erba (2025) emphasized that CBDCs may improve financial inclusion, payment transparency, and cross-border transaction efficiency. Likewise, Magnusson and Nyh (2025) argued that CBDCs could significantly disrupt international payment infrastructures by reducing transaction delays and increasing interoperability within digital financial ecosystems.

Blockchain applications in supply chain management have also gained substantial scholarly interest. Researchers argue that blockchain-enabled supply chains improve traceability, transparency, and product authenticity by enabling real-time monitoring and immutable recordkeeping. Deloitte (2022) reported that blockchain enhances supply chain coordination by facilitating secure information sharing among manufacturers, suppliers, logistics providers, and consumers. Similarly, Rajeshwari (2024) found that blockchain integration improves healthcare supply chain

efficiency by reducing fraud, enhancing inventory visibility, and improving operational responsiveness.

The integration of blockchain with artificial intelligence and digital automation systems has emerged as another important research stream. Garg and Kumar (2024) argued that the convergence of blockchain and AI enhances organizational sustainability through intelligent decision-making, predictive analytics, and secure data management systems. Jameaba (2025) further suggested that blockchain-AI integration strengthens financial stability by improving fraud detection, risk monitoring, and cybersecurity resilience in digital financial institutions.

Several scholars have also examined blockchain technology from the perspective of sustainability and digital governance. Zaher and Roy (2025) emphasized the growing relevance of blockchain in promoting sustainable finance, decentralized governance, and environmentally responsible digital infrastructures. Similarly, Menshikov et al. (2025) argued that blockchain, AI, and digital currencies collectively contribute to inclusive economic transformation by supporting transparent governance mechanisms and digital economic participation.

Despite the growing body of literature, significant gaps remain in understanding blockchain's multidimensional contribution to global economic transformation. Most existing studies focus on isolated applications such as cryptocurrencies, DeFi, or supply chains, while limited research integrates blockchain's role in economic resilience, sustainability, digital governance, AI-enabled automation, and post-pandemic economic restructuring within a unified conceptual framework. Furthermore, empirical consensus remains limited regarding blockchain's ability to simultaneously enhance transparency, institutional trust, cybersecurity, and sustainable economic growth while overcoming regulatory and technological barriers.

Therefore, the present study seeks to contribute to the literature by providing a comprehensive and conceptually integrated analysis of blockchain technology as a catalyst for global economic transformation in the contemporary digital era.

V. MAJOR APPLICATIONS OF BLOCKCHAIN TECHNOLOGY AND ITS ECONOMIC IMPLICATIONS

Blockchain technology has evolved from a cryptocurrency-supporting infrastructure into a transformative digital innovation with applications across multiple sectors of the global economy. Its decentralized architecture, transparency, immutability, and automation capabilities have enabled organizations and governments to redesign traditional operational systems and improve institutional efficiency. In recent years, blockchain adoption has accelerated due to the growing demand for secure digital transactions, efficient data management, and transparent governance mechanisms.

A. Blockchain in Financial Services and Decentralized Finance (DeFi)

The financial sector remains one of the most prominent adopters of blockchain technology. Blockchain-based financial systems facilitate peer-to-peer transactions without requiring centralized intermediaries such as banks or financial institutions. Decentralized Finance (DeFi) platforms use blockchain-enabled smart contracts to provide services such as lending, borrowing, insurance, and digital asset trading in a transparent and automated environment.

The implementation of blockchain in finance significantly reduces transaction costs, improves payment speed, and enhances cross-border financial inclusion. Furthermore, blockchain supports the development of Central Bank Digital Currencies (CBDCs), which are being explored by several countries to modernize monetary systems and improve digital payment infrastructures. These innovations contribute to economic growth by increasing accessibility to financial services and strengthening digital financial ecosystems.

B. Blockchain in Supply Chain Management

Supply chain management has emerged as another critical area where blockchain technology offers substantial benefits. Modern supply chains involve multiple stakeholders, including suppliers, manufacturers, distributors, and retailers, making transparency and traceability essential for operational efficiency. Blockchain enables real-time tracking of products and transactions through immutable distributed ledgers.

Organizations can use blockchain to monitor inventory movement, verify product authenticity, reduce fraud, and

improve logistics coordination. In sectors such as healthcare, food processing, and pharmaceuticals, blockchain enhances product safety and quality assurance by providing transparent records throughout the supply chain process. Consequently, businesses can optimize resource utilization, reduce operational delays, and improve customer trust.

C. Blockchain in Governance and Public Administration

Governments and public institutions are increasingly exploring blockchain-based governance models to enhance transparency, accountability, and administrative efficiency. Blockchain applications in public administration include digital identity management, land registration systems, taxation, public procurement, and voting systems.

The decentralized nature of blockchain reduces opportunities for corruption and unauthorized data manipulation by ensuring that records remain secure and verifiable. Smart contracts can automate administrative procedures, thereby reducing bureaucratic delays and improving service delivery. These capabilities contribute to institutional efficiency and strengthen public trust in governance systems.

D. Blockchain and Artificial Intelligence Integration

The integration of blockchain technology with artificial intelligence (AI) has created new opportunities for intelligent automation and data-driven decision-making. Blockchain provides secure and transparent data storage, while AI enhances analytical capabilities and predictive accuracy. Together, these technologies support the development of autonomous systems capable of improving operational efficiency across industries.

AI-enabled blockchain systems are increasingly being used in cybersecurity, healthcare analytics, financial risk assessment, and smart manufacturing environments. The integration also facilitates secure sharing of large datasets while maintaining privacy and data integrity. Such advancements support innovation and strengthen digital economic resilience in highly competitive business environments.

E. Blockchain and Sustainable Development

Blockchain technology also contributes to sustainable development by promoting transparency, accountability, and efficient resource management. Organizations are utilizing blockchain to monitor carbon emissions, track



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renewable energy consumption, and support environmentally responsible supply chain practices.

In the financial sector, blockchain supports green finance initiatives and sustainable investment tracking. The technology can further enhance social and economic inclusion by enabling secure digital access to financial services in underserved regions. These applications align blockchain technology with broader sustainable development objectives and environmental governance frameworks.

F. Implications of Blockchain for Economic Growth and Institutional Efficiency

The widespread adoption of blockchain technology has significant implications for economic development and institutional transformation. Blockchain enhances economic efficiency by reducing transaction costs, minimizing operational redundancies, and improving information transparency across business networks. The automation of processes through smart contracts enables faster execution of transactions while reducing dependence on intermediaries.

Blockchain also strengthens institutional trust by ensuring data integrity and accountability within digital ecosystems. Transparent and tamper-resistant records improve decision-making processes for organizations, regulators, and policymakers. In addition, blockchain facilitates greater collaboration among stakeholders through decentralized coordination mechanisms, thereby supporting innovation and productivity growth.

From a macroeconomic perspective, blockchain contributes to digital economic expansion by encouraging technological innovation, financial inclusion, and international trade efficiency. The emergence of blockchain-enabled financial systems, digital assets, and decentralized applications is reshaping traditional business models and creating new economic opportunities in the global digital economy.

VI. CHALLENGES AND LIMITATIONS OF BLOCKCHAIN ADOPTION

Despite its transformative potential, blockchain technology faces several technical, regulatory, and institutional challenges that limit large-scale adoption. One of the primary concerns is scalability, as blockchain networks often experience reduced transaction speed and increased processing costs when handling large volumes of data and users.

Cybersecurity and privacy risks also remain significant concerns. Although blockchain systems are highly secure, vulnerabilities associated with smart contracts, digital wallets, and external applications can expose organizations to cyberattacks and financial losses. Moreover, decentralized systems create governance complexities because accountability and ownership structures are often unclear.

Regulatory uncertainty represents another major challenge. Different countries adopt varying legal approaches toward blockchain, cryptocurrencies, and digital assets, resulting in fragmented regulatory environments. The absence of standardized legal frameworks complicates international blockchain implementation and creates compliance difficulties for businesses and investors.

Energy consumption associated with certain blockchain consensus mechanisms, particularly Proof-of-Work (PoW), has also attracted criticism due to environmental sustainability concerns. Additionally, interoperability issues among different blockchain platforms limit seamless integration across industries and digital ecosystems.

Finally, limited technological awareness, lack of skilled professionals, and high implementation costs continue to restrict blockchain adoption, particularly in developing economies and small-scale enterprises.

VII. POLICY IMPLICATIONS

To maximize the economic benefits of blockchain technology, governments and regulatory authorities must establish balanced and innovation-friendly policy frameworks. Clear legal guidelines regarding digital assets, smart contracts, decentralized finance, and data protection are essential for reducing uncertainty and encouraging responsible blockchain adoption.

Policymakers should also promote investment in digital infrastructure, cybersecurity systems, and blockchain research initiatives. Public-private collaboration can further accelerate blockchain innovation by supporting pilot projects, industry partnerships, and technology incubation programs.

Educational institutions and professional organizations should emphasize blockchain-related training and skill development to address the growing demand for qualified professionals. Furthermore, international cooperation is necessary to develop standardized regulations and interoperability frameworks that support cross-border blockchain integration and digital trade efficiency.



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VIII. FUTURE RESEARCH DIRECTIONS

Future research should focus on the integration of blockchain with emerging technologies such as artificial intelligence, the Internet of Things (IoT), quantum computing, and cloud-based infrastructures. Additional empirical studies are required to evaluate the long-term economic impact of blockchain adoption on productivity, employment, financial inclusion, and institutional performance.

Researchers may also investigate the role of blockchain in promoting sustainable development goals, environmental governance, and green finance systems. Comparative studies examining blockchain adoption across developed and developing economies could provide valuable insights into regional challenges and implementation strategies.

Further investigation is also needed regarding blockchain governance models, regulatory frameworks, cybersecurity mechanisms, and ethical implications associated with decentralized systems. The growing adoption of CBDCs and DeFi platforms presents additional opportunities for future interdisciplinary research in economics, finance, public policy, and information systems.

IX. CONCLUSION

Blockchain technology has emerged as one of the most influential digital innovations shaping the contemporary global economy. Its decentralized architecture, transparency mechanisms, and automation capabilities have expanded its applications far beyond cryptocurrencies into sectors such as finance, governance, healthcare, manufacturing, and supply chain management. By improving operational efficiency, enhancing trust, reducing transaction costs, and strengthening cybersecurity, blockchain contributes significantly to digital economic transformation and institutional modernization.

The study demonstrates that blockchain possesses substantial potential to support sustainable economic growth, financial inclusion, digital governance, and resilient organizational systems. Emerging applications such as decentralized finance, smart contracts, AI-blockchain integration, and Central Bank Digital Currencies are further accelerating the transition toward intelligent and decentralized digital ecosystems.

However, the widespread adoption of blockchain technology remains constrained by challenges related to scalability, regulatory uncertainty, cybersecurity risks, interoperability limitations, and energy consumption

concerns. Addressing these issues requires coordinated efforts from governments, businesses, researchers, and regulatory institutions to develop effective governance frameworks and sustainable implementation strategies.

Overall, blockchain technology represents a transformative force capable of reshaping economic systems, governance structures, and digital interactions in the modern era. With appropriate regulatory support, technological advancement, and institutional collaboration, blockchain can play a critical role in building a more transparent, secure, efficient, and sustainable global economy.

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