

The Role of Blockchain Technologies in Combating Corruption within the Virtual Assets Realm

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Abstract

The utilisation of blockchain technology can greatly hinder the perpetration of corrupt deeds owing to its data immutability and transparency. The purpose of the study is to assess the impact of blockchain integration on reducing corruption risks in the realm of virtual assets. It was found that since the introduction of blockchain, Estonia has almost doubled the ranking of countries in anti-corruption. According to the study, the volume of illegal cryptocurrency transactions continues to grow, requiring financial systems to adapt to new challenges. The prospect of further research should be based on strengthening financial security. The scientific novelty lies in the recognition of blockchain technologies' potential as a tool for ensuring transparency and information inviolability within the virtual assets realm. The practical value of the study lies in developing recommendations for integrating blockchain technologies into virtual assets' control and audit, which will contribute to enhancing the effectiveness of anti-corruption measures.

Keywords: Blockchain technologies, corruption, virtual assets, cryptocurrencies, financial security, smart contracts.

Introduction

The problem of using blockchain technologies to combat corruption within the realm of virtual assets is of particular relevance in the modern digital world. Reports on the development of the blockchain market, published by the Blockchain Technology Market (2023), evaluate the general expansion and

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integration of blockchain technologies across diverse sectors as their capacity to combat corruption continues to gain momentum. As the prevalence of cryptocurrencies and other forms of virtual assets increases, so do the opportunities for abuse, including money laundering, terrorist financing, and other corrupt practices. Traditional methods of combating such offences are often ineffective, as virtual assets provide significant anonymity and facilitate prompt cross-border transfer of funds. Blockchain technologies offer a novel approach to solving the problems of hidden transactions that can significantly complicate corrupt (Alnaimat et al., 2023).

In Europe, according to Ghadekar et al. (2023), due to progressive regulatory policy and openness to innovation, the use of blockchain technologies to combat corruption in virtual assets has already yielded positive results. To ensure greater transparency and efficiency, European countries actively research and implement blockchain solutions in various areas, from financial services to public administration. Particularly conspicuous is the application of public procurement mechanisms, maintaining property registers, and other government operations where blockchain helps reduce opportunities for corruption abuses. Overall, initiatives at the European Union level highlight the region's commitment to explore further and use blockchain to increase transparency and reduce corruption.

During the past few years, the development of the blockchain technology market has shown dramatic changes in terms of its growth case (Mihus, 2022), which reflects the increased interest in digital assets and the expansion of their applications. From 2019 to 2024, the blockchain market has undergone significant changes, increasing more than tenfold, highlighting the rapid adoption of this technology in various sectors of the global economy. The said trend is driven by the need for transactions' transparency and efficiency, heightened interest in cryptocurrencies as an investment asset class, and the development of decentralised finance. They have provided novel prospects for users, eliminating the need to resort to conventional financial establishments. Accordingly, opportunities for blockchain technology development in financial institutions open new horizons for increasing transparency, security, and efficiency in managing virtual assets. Digital technologies make it possible to create transparent platforms for tokenising assets, which paves the way for new investment forms and simplifies the procedures for buying and selling securities.

According to the study by Yfantis and Ntalianis (2022), blockchain-based tracking technologies are revolutionising approaches to virtual asset management by offering cutting-edge solutions for real-time transaction monitoring and

analysis. The implementation of blockchain technology facilitates the establishment of reliable and unalterable records of financial dealings, a crucial aspect in identifying illicit monetary transactions such as money laundering or terrorist financing. Contemporary blockchain-based platforms furnish superior data protection, empowering financial entities to track the origin of virtual assets and their path through different jurisdictions.

The purpose of the study is to assess the impact of blockchain technologies in combating corruption within the realm of virtual assets.

Research Objectives

Within the framework of the study, the primary objectives were identified as follows:

1. To ascertain the correlation between the degree of assimilating blockchain technologies into a nation's financial infrastructure and the mitigation of corrupt practices within organisations dealing in digital assets, drawing upon Estonia's experience.
2. To identify the statistical features of the blockchain application market and the effectiveness of the fight against corruption within the virtual assets realm, focusing on a comparative analysis of the market and illegal transactions.
3. To develop recommendations for improving the integration of blockchain technologies to mitigate corruption within the virtual assets realm, based on the results obtained, including proposals for reforming legislation, technological approaches and practices in financial institutions.

Materials and methods

The research procedure covers the analysis of the blockchain market, the circulation of illegal transactions, Estonia's struggle to draw upon this technology, and several recommendations for its implementation. Data from Chainalysis (2023) provides a unique view of cryptocurrencies and offers a distinctive account of cryptocurrencies misuse, including how the latter are used for illegal purposes, money laundering, and the funding of illicit endeavours. Using data from Transparency International (2023) and CorruptionRisk (2023) helps assess the corruption level across different countries and understand how blockchain implementation can affect these indicators. Content analysis of academic literature, reports, and research provides a profound insight into theoretical and practical aspects of utilising blockchain to combat corruption, making it possible to identify the most effective strategies and approaches.

The research methods are based on the statistical methods for processing the data obtained. The utilisation of quantitative methodologies enables the

examination and assessment of accessible data, identification of patterns and trends, and evaluation of the impact of blockchain technologies on reducing corruption risks within the realm of virtual assets.

The research sample encompasses the worldwide implementation of blockchain technologies in combating corrupt practices, with a special focus on Estonia. The country was chosen because of its leading role in embracing digital technology in government processes, including using blockchain as a top priority. Estonia is a recognised leader in digitalising public administration, making the nation a distinctive example of a research paradigm. The introduction of e-government, e-residency, and other innovative blockchain projects have provided Estonia with a high level of transparency and efficiency in the fight against corruption. The analysis of Estonia's experience allows us to assess the impact of blockchain on improving management processes and reducing corruption and hence identify potential challenges and limitations that other countries may face when integrating such technologies.

The analysis tools used in the study cover a wide range of methodologies for processing and interpreting statistical data obtained from various sources, including quantitative data collected from reports by Chainalysis, Transparency International, and other authoritative databases, allowing for an in-depth analysis of trends related to utilising blockchain and its impact on the corruption level across various countries.

The centrality of research ethics is paramount in the methodology utilised for data collection, processing, and analysis. It is indispensable to ensure that all information used in the research is obtained and presented with respect for intellectual property rights and that the information confidentiality and personal data are adequately protected. Adherence to high ethical standards implies transparency in presenting research methods and impartiality in scrutinising attained outcomes. This methodology enhances the empirical accuracy and validity of the investigation, guarantees its societal accountability, and fosters advancements in understanding the effects of blockchain technologies on society.

Literature Review

The challenges of the utilisation of blockchain technologies in combating corruption within the realm of the virtual asset highlight a profound understanding of the potential and challenges associated with integrating these technologies into modern economic and social processes. The studies by César and García (2021) and Levytska et al. (2022) maintain that blockchain offers revolutionary opportunities to ensure transparency, reduce corruption risks, and increase trust in financial systems. According to Danylkiv et al. (2022), the intensive use of

blockchain analytics contributes to identifying and combating cybercrime in cryptocurrencies. Another scholar (Davis et al., 2022) argues that challenges and limitations are associated with scaling blockchain technologies and integrating them into existing financial systems. The research conducted by Sarker et al. (2021) delves into the intricate technical and regulatory obstacles that must be surmounted to fully capitalise on the boundless possibilities of blockchain technology. The significance of establishing global standards and legal frameworks to govern the flow of virtual assets and utilisation of blockchain technology is emphasised by Kraft and Kellner (2022). Amponsah et al. (2022) contend that successful blockchain implementation necessitates technological advancements, alongside legislative policies and modifications to regulatory practices. The article (Ravy et al., 2023) characterises the experience of European countries, which serves as an important case for research, as it demonstrates the ability of blockchain to influence effective governance and reduce corruption risks at the state level. The assertions put forth by Berdaliyeva et al. (2023) evaluate the holistic influence of technological advancement on the prevalence of corruption within a nation, reinforcing the argument about the positive impact of blockchain on reducing corruption. Still, another researcher (Pandey & Litoriya, 2020) perceives blockchain as a technological advancement and a potent instrument for societal transformation, capable of exerting influence over power dynamics and governance frameworks. The hypothesis (Baudier et al., 2023) indicates that blockchain offers opportunities to increase government operations transparency and mitigate corruption through records immutability and responsibility decentralisation. The paper (Halai et al., 2021) focuses on successful examples of implementing blockchain technologies in EU countries' state institutions, where digital property registers and e-procurement systems have already shown their effectiveness in preventing corruption schemes. Further, Bezpалov and Remeslennikov (2019) highlight the critical aspects and potential risks associated with the rapid development of blockchain technologies and the need to improve the legal framework that would allow the full use of the potential of blockchain in the fight against corruption. In this light, Quayson et al. (2021) underscore the imperative for a more profound scrutiny of blockchain's potential in safeguarding digital security, particularly in data protection and user privacy. The article by Benítez-Martínez et al. (2023) focuses on the importance of international cooperation and the development of common standards in the field of blockchain to ensure the effective interoperability of systems at the global level. In the opinion Mihus (2022), the EU countries' experience in developing strategies for using blockchain to increase the transparency of budget processes and public procurement serves as a model for other regions. According to Trequattrini et al.

(2023), blockchain can revolutionise the public procurement system, reducing opportunities for corruption abuses. Further analysis (Gonçalves & Domingos, 2021) shows that using blockchain technologies in voting systems can significantly increase reliability and transparency. According to (Vinnykova, 2022), integrating blockchain into the financial sector of EU countries helps reduce the risks of money laundering. The research conducted by Luciano et al. (2020) emphasises the significance of blockchain technology in establishing decentralised identity systems that can effectively combat corruption. Furthermore, the paper (Miraj, 2023) describes ensuring transparency in supply chains based on digital infrastructure. Thus, blockchain technologies have great potential in the fight against corruption, especially in European countries.

Results

Advancements in smart contract technologies and immutable blockchain records are propelling the utilisation of blockchain applications in anti-corruption policy and governmental entities. The substantial surge in market volume necessitates formulating novel protocols and policies designed to safeguard investors and consumers, combating money laundering and terrorist financing through cryptocurrencies. The current size of the blockchain technology market is shown in Figure 1.

In light of the rapid development of the blockchain technology market, it is imperative to integrate such technologies into governmental bodies and financial institutions' operations to counteract corruption. According to Gumarov and Farakhiev (2022), comprehending the necessity of incorporating blockchain technology into financial institutions to mitigate corruption and implicit financial transactions necessitates an extensive comprehension of the challenges the contemporary financial system faces. The constant growth in the volume of hidden transactions within the realm of cryptocurrencies requires governments, regulators, and financial institutions to intensify efforts aimed at implementing innovative technological solutions, of which blockchain is one of the most effective. The use of blockchain to ensure the transactions' transparency and security can be a key factor in creating a more resilient and open financial ecosystem capable of effectively confronting the corruption challenges of our time. The surge in the value of cryptocurrencies that are eventually directed at transfer addresses is evidence that as the popularity and adoption of digital currencies is on the rise, so is their use for illicit purposes. Data from Figure 2 (Chainalysis, 2023), showing an increase from \$4.9 billion in 2017 to \$20.6 billion in 2022, points to the need to strengthen mechanisms for tracking and controlling cryptocurrency transactions. The importance of integrating blockchain

technologies into financial systems is evident in combating money laundering, terrorist financing, and other forms of financial crime. Integrating blockchain technology can facilitate identifying and preventing unlawful transactions while promoting legitimacy and transparency in financial transfers.

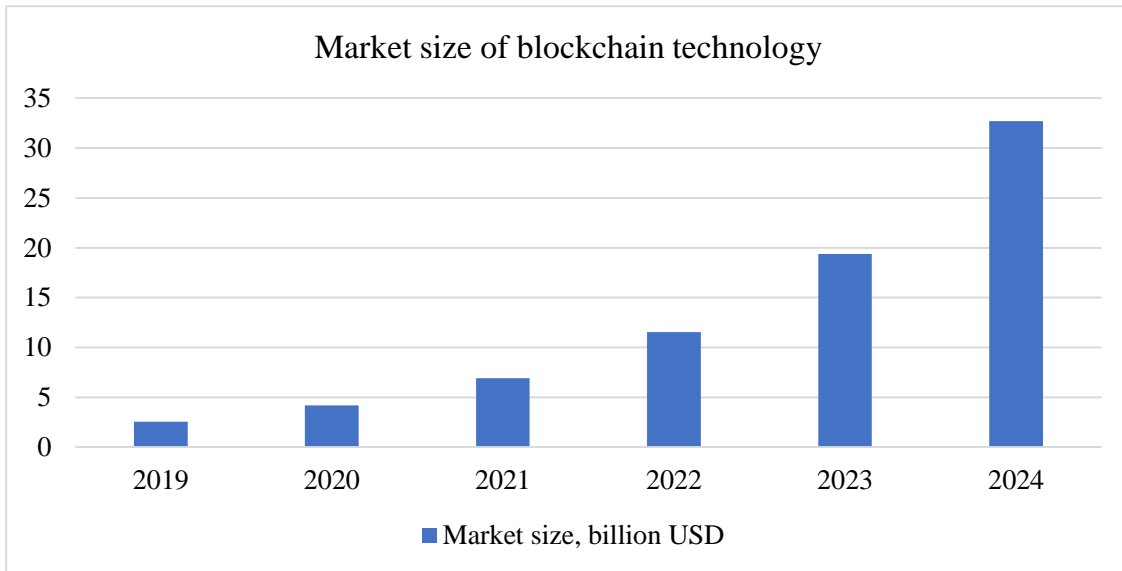


Figure 1. Market size of blockchain technology

Source: developed by Precedence Research

*projected volume in 2024

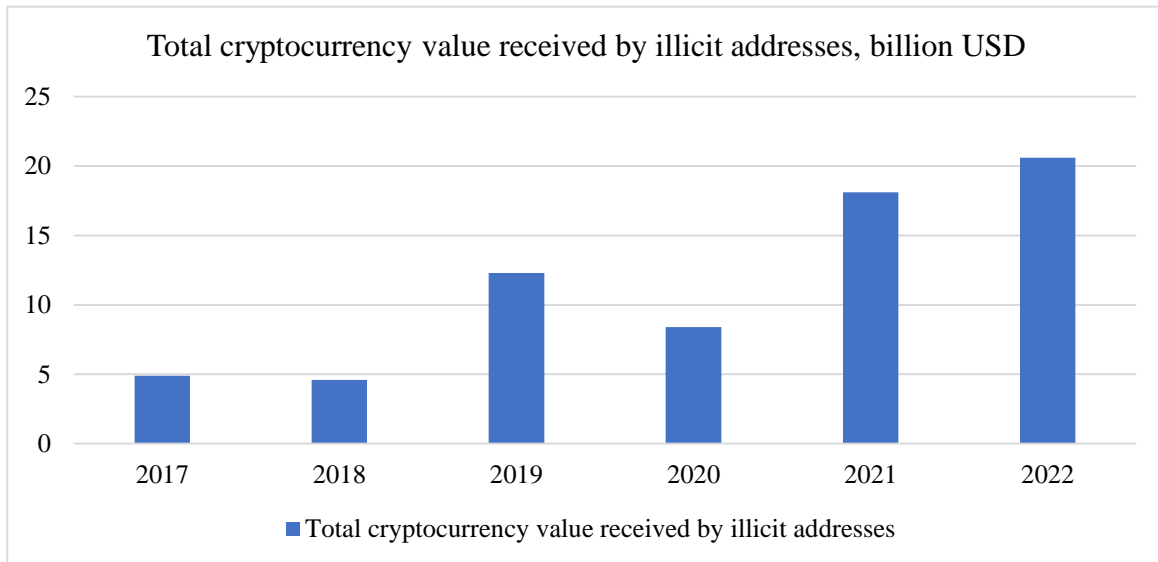


Figure 2. Total cryptocurrency value received by illicit addresses, billion USD

Source: compiled from the Chainalysis (2023) Report

The total value of cryptocurrency received at anonymous addresses in USD billions from 2017 to 2022 reflects the alarming upward trend in using cryptocurrencies for illicit purposes. The sharp increase from \$4.9 billion in 2017 to \$12.3 billion in 2019 and then to \$20.6 billion in 2022 indicates gaining in the size of the cryptocurrency market and an increase in the complexity and volume of criminal activity associated with their use. The developments are related to various aspects, including an increase in the total number of cryptocurrency transactions. The advancements pertain to diverse facets, encompassing a surge in the total number of digital currency transactions, the emergence of new types of fraud and cybercrime, and the use of cryptocurrencies for money laundering and terrorist financing. The dynamics highlight the importance of developing and implementing new methods and technologies to monitor and analyse cryptocurrency transactions to identify and prevent hidden financial flows.

Blockchain provides immutability and transparency in records, making it an ideal tool for monitoring and auditing financial transactions at any level. The technology makes it possible to detect illegal financial flows while protecting confidential information through cryptographic methods. In the study Blockchain Technology Market (2023), blockchain facilitates the control processes automation through the use of smart contracts that can automatically fulfil certain conditions of transactions, significantly reducing the risk of human error or deliberate interference. That said, the innovation improves the ability to detect illicit assets and transactions and contributes to creating a more transparent and responsible financial system. Furthermore, the application of blockchain to fight corruption goes far beyond the financial sector, encompassing government, healthcare, education, and other areas. Due to its ability to provide genuine and easily accessible accounts, blockchain can guarantee transparency in government procurement, voting, and other processes, which are often the targets of corrupt practices. Estonia's experience shows a positive trend in reducing corruption from introducing blockchain, the results of which are presented in Table 1.

Table 1

Corruption perceptions index in Estonia

Score	Year	Rank
73	2018	18
74	2019	19
75	2020	17
74	2021	13
74	2022	14
76	2023	12

Source: compiled by Transparency International (2023)

Estonia's experience integrating blockchain technologies is one of the most impressive examples of their effective application. Due to its early implementation of digital technologies, including blockchain, Estonia has substantially decreased the prevalence of corruption within the nation. This achievement is validated by its impressive standing in global rankings. According to Table 1, from 2018 to 2023 (Transparency International, 2023), Estonia has steadily enhanced its performance in combating corruption, achieving a score of 76 points in 2023 and rising to 12th place in the ranking. The above achievements were made possible by the widespread adoption of blockchain in public administration. It should be noted that the main problem area of Estonia was the improvement of the state's online services and procurement efficiency, the result of which is shown in Table 2.

Table 2

Components of blockchain's role in combating corruption in virtual assets

Components	2013	2023
Budget transparency	8.07	8.07
Judicial independence	7.81	7.73
Freedom of press	9.17	8.68
E-citizenship	5.83	6.92
Online services	8.41	10

Source: compiled by CorruptionRisk (2023) Report

Estonia's digital advancement has been achieved by implementing cutting-edge technology across diverse sectors, including healthcare, education, public procurement, and real estate registration. As a result (Semenzin et al., 2022), Estonia has emerged as one of the most technologically advanced countries in the world. Notably, Estonia's triumph has captured the attention of other nations endeavouring to employ blockchain technology in combating corruption and enhancing public administration efficiency. Since 2022, the nation's progress has only improved, serving as a global example of how strategic implementation of innovative technologies can result in substantial enhancements regarding transparency, openness in public administration, and minimal levels of corruption. The Estonian experience inspires many countries worldwide by emphasising the significance of technological innovation towards developing a more equitable and accessible society.

Given the above, Ukraine should implement a strategy for building infrastructure using blockchain technologies to fight against corruption in virtual assets, which will require a comprehensive approach, including developing technical standards, legal frameworks, and governance mechanisms. Article (Parenti et al., 2022) contests the strategy aims to guarantee the seamless technical integration of diverse blockchain platforms while ensuring that their operations align with legal regulations and global standards. A crucial component of incorporating blockchain technology into Ukraine's sphere is establishing robust monitoring and assessment mechanisms to identify and prevent activities in real-time. The effectiveness of this fight can be greatly enhanced by developing specialised software that integrates artificial intelligence and machine learning algorithms to analyse transactions and identify suspicious schemes. The fight against corruption in Ukraine is of immense public concern. Hence, virtual assets necessitate cooperation among governmental bodies, financial establishments, and blockchain innovators to exchange expertise and optimal strategies. The basic principles of this practice are presented in Table 3.

Table 3

Principles of blockchain technology in combating corruption

Principle	Function	Technology
Transparency	Blockchain provides a high transparency level, allowing for real-time tracking of transactions.	Open access to the transaction history of cryptocurrencies - Ethereum, Bitcoin, Hyperledger Fabric
Immutability	Records on the blockchain cannot be changed or deleted, which prevents falsifications and corruption.	Using blockchain to register land rights - IPFS (InterPlanetary File System)
Decentralisation	The lack of a unified regulatory entity complicates of corrupt practices.	Cryptocurrency exchanges that don't have a central admin – DeFi platforms (Uniswap, Compound)
Automation through smart contracts	Smart contracts automatically execute trades based on preset conditions, reducing human error and corruption.	Automatic issuance of insurance payouts in the event of an insured event - Chainlink
Identification of Asset Owners	Technologies such as blockchain can help in identifying and verifying virtual assets owners.	Use of digital identifiers for cryptocurrency holders - Self-sovereign identity systems (uPort,

Source: compiled by the author

Utilising blockchain technology for recording ownership of virtual assets facilitates the establishment of an immutable ownership record, rendering it impossible to conceal or fabricate data about owners. Slatvinska et al. (2022) show that this is particularly crucial in a realm where transactional anonymity can instigate illicit activities such as money laundering and other forms of corruption. Integrating blockchain technology into monitoring and reporting systems can facilitate the detection of aberrations and dubious changes in virtual assets circulation, facilitating a rapid response to possible violations. Using smart contracts to automate transactions and meet regulatory requirements can further reduce the scope for corrupt practices, as each transaction takes place under pre-established rules and conditions that ensure its legitimacy and transparency. Applying deep learning algorithms can help identify complex connections between transactions and accounts, revealing hidden patterns that would not be apparent in traditional analysis. Using blockchain to create a single, immutable database of transactions allows for a complete, transparent audit trail for each virtual asset, ensuring a high level of responsibility and openness in virtual assets. The technology ecosystem paves the way for innovation and economic growth, laying the foundation for a fairer and more open society where citizens' core values and rights are protected through the transparency and immutability of blockchain technologies. Thus, blockchain is becoming a powerful tool not only for preventing and detecting corruption but also for increasing trust and security within the realm of virtual assets.

Discussion

The investigation findings share numerous similarities with the deductions drawn by other scholars. According to the study (George & Al-Ansari, 2023), blockchain significantly improves the transparency and efficiency of transaction tracking, which aligns with our observations about reducing the risk of corruption in financial institutions. In contrast to Heshan Sameera et al. (2021), who argues that blockchain integration may be limited due to the high technology costs, the study shows that the market is constantly capitalised and growing. We agree with the opinion of the scholars (Yfantis & Ntalianis, 2022) that the use of blockchain for cryptographic data protection provides a higher security level, the reason for which is the encryption records uniqueness, so this is consistent with our conclusions about blockchain effectiveness in protecting against illegal access and abuse of virtual assets. Gumarov and Farakhiev (2022) have established that

international cooperation and standardisation in implementing blockchain technologies are the moare. Still, other scholars, Hubanova et al. (2021), emphasise the need for a global regulatory framework to ensure the interoperability and security of cross-border transactions, which is confirmed by the significant popularity of the technology development. Our findings on blockchain prospects in tracking virtual assets align with Ogunlela's et al. results (2021), which demonstrate the success of blockchain platforms in combating financial crimes. The issues outlined in the study (Slatvinska et al., 2022) regarding the energy efficiency of blockchain systems remain important challenges for their wider adoption. The study confirms the findings (Wang et al., 2020) that blockchain has significant potential in combating corruption in the field of virtual assets but points to the need for further research and technology development to overcome existing limitations. The efficacy enhancements achieved through monitoring are substantiated by empirical evidence (Parenti et al., 2021), which indicates a decrease in illicit transactions in systems using blockchain compared to traditional financial infrastructures. We agree with Ghadekar et al. (2023) that the technology should increase user awareness of the use of virtual assets. In contrast to Semenzin's et al. (2022) findings, our analysis highlights the promising prospects of blockchain technology in enhancing transactional transparency and security within electronic government services. This is exemplified by Estonia's successful integration of this technology, which is a noteworthy model for other nations to emulate. Therefore, the prevalent challenges underscore the necessity of adopting a holistic strategy toward utilising blockchain technology in combating corruption. This approach should encompass technological advancements, legal frameworks, and education for users and regulatory bodies.

Conclusion

Thus, the significance of blockchain technologies in combating corruption within the virtual assets domain has been demonstrated, paving the way for new horizons in ensuring transparency, security, and responsibility in the management and circulation of digital assets. Blockchain integration ensures records immutability, processes automation through smart contracts, and decentralisation, which complicate the commission of corrupt acts and contribute to effective fraud detection and prevention. Using this technology in different countries and industries demonstrates its high effectiveness in combating corruption, creating transparent systems for monitoring transactions, and managing virtual assets. Technology paves the way for a more open and fair financial system, where every

transaction is transparent and verified, minimising the risks of corruption and abuse.

Despite its many advantages, the integration of blockchain technologies into the virtual assets realm faces several obstacles and global challenges. These include the issues of scaling, power consumption, regulatory ambiguity, and the need for standardisation. Notably, scaling blockchain systems requires significant technological innovation to support the growing number of transactions without sacrificing speed and efficiency. High power consumption, especially in networks with a Proof of Work consensus mechanism, raises the issue of environmental sustainability. Furthermore, the interaction complexity between blockchain platforms is heightened by regulatory ambiguity and the absence of consistent international standards, traditional financial systems, and the legal field, which may hinder their wider adoption and implementation. Thus, such challenges require careful attention and collaboration between technology experts, regulators, governments, and international organisations to develop effective solutions.

In line with the above challenges, the recommendations and expedient measures should be aimed at developing a flexible, resilient regulatory environment that fosters innovation and user protection. It is imperative to develop international standards for blockchain technologies that will ensure their interoperability, security, and efficiency at the global level. Responsibilities encompass establishing uniform procedures for scrutinising and examining digital assets, and formulating ethical principles governing blockchain usage to preclude exploitation. A significant measure is to allocate resources towards researching and creating energy-conserving blockchain frameworks that reduce carbon footprint and ensure scalability. It is crucial to enhance collaboration between governmental and commercial entities to implement blockchain solutions in the virtual assets realm, which involves the joint development of legal frameworks and technological innovations. Accordingly, it is important to provide educational support and raise awareness among all stakeholders about the benefits and risks associated with blockchain use to form a responsible and educated approach to virtual assets management.

Recommendations

To harness the full potential of blockchain technologies in combating corruption within the virtual assets realm, it is crucial to focus on their key advantages and strategic implementations:

1. Leverage the decentralisation feature of blockchain to eliminate central intermediaries, thereby reducing opportunities for corrupt practices.

2. Ensure transparency and accountability by recording transactions and digital asset ownership on a distributed ledger accessible to all participants.
3. Utilise the immutability of blockchain records to prevent the alteration or deletion of transactions, making it challenging for corrupt individuals to manipulate or hide illicit activities.
4. Implement smart contracts to automate the execution of agreements based on predefined conditions, thereby reducing human intervention and the associated corruption risks.
5. Create a secure and tamper-proof environment for storing and transferring digital assets, addressing many security concerns and making blockchain a powerful tool against corruption.

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