Data and Metadata. 2024; 3:461
doi: 10.56294/dm2024461

ORIGINAL

Analysis of the use of blockchain technologies and smart contracts to automate management processes and ensure sustainability

Análisis del uso de tecnologías blockchain y contratos inteligentes para automatizar procesos de gestión y garantizar la sostenibilidad

Valentyn Bannikov[1], Stanislav Petko[2], Oleksandr Semenov[3], Oleksandr Zhurba[4], Kateryna Lohinova[5]

[1]DataArt. New York, USA.
[2]Kyiv National Economic University named after Vadym Hetman. Kyiv, Ukraine.
[3]Department of Electromechanics, Robotics, Biomedical, Faculty of Energy, Robotics and Computer Technologies, State Biotechnological University. Kharkiv, Ukraine.
[4]Department of Economics and Competition Policy, State University of Trade and Economics. Kyiv, Ukraine.
[5]Department of Management and Business, Simon Kuznets Kharkiv National University of Economics. Kharkiv, Ukraine.

Cite as: Bannikov V, Petko S, Semenov O, Zhurba O, Lohinova K. Analysis of the use of blockchain technologies and smart contracts to automate management processes and ensure sustainability. Data and Metadata. 2024; 3:461. https://doi.org/10.56294/dm2024461

Submitted: 20-02-2024 **Revised:** 11-05-2024 **Accepted:** 31-07-2024 **Published:** 01-08-2024

Editor: Adrián Alejandro Vitón Castillo

ABSTRACT

Introduction: this paper discusses and analyzes how blockchain technologies and smart contracts apply to automate assurance management processes with sustainability using a perspective model. The increase in demand for systems that are clear and secure in the automation of management processes calls for innovations such as blockchain and smart contracts.
Objective: the objectives of the article are to identify the status of blockchain and smart contract adoption in many management processes; to consider the effect these technologies have on the efficiency, transparency, and sustainability of management operations.
Methodology: we used regression and Markov analysis simulations to analyze the impacts of blockchain technologies on the management processes. The case study data were used to predict the long-term sustainability impacts, and simulations were carried out.
Results: the regression established a positive but substantial effect of the adoption of blockchain technologies on the efficiency of management processes. 75 % of the efficiency score varies with the level of blockchain adoption. Simulations done using the Markov chain also showed that under the highest level of blockchain adoption, there is an effectivity of 90 percent where management processes would have improved and be efficient for the remaining ten years. The simulations also attested that partial adoption still offered a 70 % probability of sustained improvements.
Conclusions: this paper provides strong evidence through regression analysis and Markov simulations showing the influence of these technologies. The ability of organizations to focus on innovative solutions toward sustainable management results is therefore realized.

Keywords: Blockchain Efficiency; Process Automation; Smart Contracts; Digital Transformation; Decentralized Management; Supply Chain Optimization.

RESUMEN

Introducción: este artículo discute y analiza cómo las tecnologías blockchain y los contratos inteligentes se aplican para automatizar los procesos de gestión de aseguramiento con sostenibilidad utilizando un modelo de perspectiva. El aumento de la demanda de sistemas que sean claros y seguros en la automatización de los procesos de gestión exige innovaciones como blockchain y los contratos inteligentes.

Objetivo: los objetivos del artículo son identificar el estado de blockchain y la adopción de contratos inteligentes en muchos procesos de gestión; considerar el efecto que estas tecnologías tienen en la eficiencia, transparencia y sostenibilidad de las operaciones de gestión.
Metodología: utilizamos simulaciones de regresión y análisis de Markov para analizar los impactos de las tecnologías blockchain en los procesos de gestión. Se utilizaron los datos del estudio de caso para predecir los impactos de sostenibilidad a largo plazo y se realizaron simulaciones.
Resultados: la regresión estableció un efecto positivo pero sustancial de la adopción de tecnologías blockchain en la eficiencia de los procesos de gestión. El 75 % de la puntuación de eficiencia varía con el nivel de adopción de blockchain. Las simulaciones realizadas mediante la cadena de Markov también mostraron que, en el nivel más alto de adopción de blockchain, existe una eficacia del 90 % en la que los procesos de gestión habrían mejorado y serían eficientes durante los diez años restantes. Las simulaciones también atestiguaron que la adopción parcial seguía ofreciendo una probabilidad del 70 % de mejoras sostenidas.
Conclusiones: este trabajo aporta pruebas sólidas mediante análisis de regresión y simulaciones de Markov que demuestran la influencia de estas tecnologías. Por lo tanto, se pone de manifiesto la capacidad de las organizaciones para centrarse en soluciones innovadoras hacia resultados de gestión sostenibles.

Palabras clave: Eficiencia Blockchain; Automatización de Procesos; Contratos Inteligentes; Transformación Digital; Gestión Descentralizada; Optimización de la Cadena de Suministro.

INTRODUCTION

When it comes to efficiency, security, and openness, many industries have been impacted by the advent of blockchain and smart contracts. Blockchain technology is what makes digital currencies like Bitcoin work.[1,2] It began as a shared ledger that anyone with an internet connection could check. Its usage is rapidly expanding across many industries, including government, healthcare, banking, and supply chain management. An immutable record of all transactions is maintained by a distributed ledger system. With this in place, it's even more secure. The likelihood of dishonesty and fraud decreases significantly when middlemen are eliminated.[3,4] A "distributed ledger" that records transactions in separate blocks is the central component of blockchain technology.[5] Each block contains the cryptographic hash of the block preceding it, and they are all connected in a string. This setup prevents unauthorized parties from tampering with previously recorded transactions, ensuring the data remains secure.

Nodes, which are groups of computers, are responsible for updating the ledger instead. A smart contract rules are codified in code and which can execute independently.[6] So long as specific criteria are satisfied, they guarantee that the contract's provisions will be adhered to at all times. So, smart contracts cut down on transaction costs, speed up the process, and stop people from messing up or misusing things, so there is no need for a third party to be involved. It is helpful to be able to automate processes when managing them, especially when doing complicated and repetitive tasks quickly and easily. Smart contracts and blockchain technology could make it possible to automate a lot of the tasks that come with management.[7]

Chin management will be able to see how things are tracked from start to finish with blockchain. This will make sure that every step of the process is recorded and checked. This not only makes things clearer, but it also keeps inventory efficient and cuts down on replicas. Along this line of financial management, intelligent contract implementation will mechanize the payment processes, ensuring enforcement of compliance with regulatory requirements and making record-keeping as accurate as possible.

The climax of contemporary management practices today is sustainability. Organizations are now considering sustainable operations that have the most negligible impact on the environment and cultivate social responsibilities.[8] These two aspects can best be achieved through blockchain and smart contracts. The blockchain will help organizations track and report all their sustainability metrics, supported by transparent and verifiable records. Smart contracts will be used to make sure that set standards on sustainability are followed, with the automatic triggering of corrections in the course of deviations from the stipulated course.

The importance of this research lies in the fact that it comprehensively studies the relationship between blockchain technology, smart contracts, and sustainable management. Earlier research has looked at these technologies in isolation; the integration provided here will supply a more holistic view and understanding of how the combined impact could influence management processes. By deploying regression analysis and Markov simulations, the paper will provide solid and data-based insights that can guide future implementations and policy decisions.

While many works have pointed out efficiency gains due to blockchain and smart contracts, a few have focused on their potential to bring sustainability to management practices. Further, the implementation of advanced analytical techniques in the form of regression analysis and Markov simulations heralds new thinking in terms

of the conduct of the research, which goes on to probe the long-term effects of technologies scrupulously. In seeking to examine the current state of adoption, the present study adds invaluable knowledge to the existing literature on blockchain technology, smart contracts, and sustainable management in both analyses regarding impacts and predictions about future outcomes. This paper looks into how blockchain technologies and smart contracts can be used in automating management processes and for sustainability. This therefore, identifies the following research aims:

1. Identify the status of blockchain and smart contract adoption in many management processes.
2. Consider the effect these technologies have on the efficiency, transparency, and sustainability of management operations.
3. Use regression to quantify the relationship between the adoption of blockchain and management efficiency.
4. Use Markov simulations to predict the long-term sustainability outcome of implementing blockchain.

Literature review

The integration of blockchain technology with smart contracts in various sectors has lately drawn relatively strong academic and industry interest because of their disruptive capability on established and traditional procedures. This literature review outlines the current state of research dealing with using blockchain and smart contracts in management processes, their impact on sustainability, and the methodologies applied in this field of study. The review shall, therefore, strive to note critical studies and their findings and find some gaps that lay a foundation for the present study.

Since blockchain is, by nature, a decentralized system and also immutable, this has enormous benefits for management processes across various industries.[9] In this way, it offers a safe, transparent, and efficient way of recording transactions and data management, which can be applied to multiple management processes. Many studies have ventured into its applications in various domains, which prove how much traditional management practices could be revolutionized.

Supply Chain Management

Among the most prominent use cases of blockchain technology is its use in supply chain management.[10] For both stakeholders, it can significantly enhance the transparency and traceability of every step on the road of a product from the manufacturer to the customer by recording every transaction and movement of goods on a tamper-proof ledger. This transparency is essential in several ways: it helps in diminishing fraud and counterfeiting, allows for tracking in real-time, and generally enhances supply chain efficiency.[11] With blockchain being able to securely and immutably record every transaction, fraudulent activities will have nowhere to hide. This has great importance in areas that are connected with medicines and luxury goods.

Another significant benefit of the use of blockchain technology in supply chain management is the aspect of real-time product tracking. Blockchain grants stakeholders the most explicit, real-time view of the supply chain, meaning they can watch products moving from the source to their final destination.[12] Bottleneck identification with real-time visibility could go on further to help optimize logistics and operational efficiency. Dutta et al.[13] undertook detailed research into the applicability of blockchain technology within supply chains, which should be in an excellent position to provide end-to-end visibility and, as a result, enhance trust between participants in the supply chain. They find that the technology enables real-time trackability of products, hence increasing operational efficiency and mitigating risks arising from any supply chain disruption.

Considering that, in this researcher's work, it takes much effort and much cost to find the best solution for such conditions, since the number of input parameters is very high and there are many associated constraints, such an approach may be possible only about the management processes. Muliarevych[14] presents the predictive model and employs serverless computing for quick search of the best results, thus increasing automation of warehouse design processes. The same can be applied to Blockchain technologies and smart contracts to automate another management process toward sustainability. Applying predictive models and serverless computing allows organizations to manage complex variables and constraints in an efficient manner, thereby optimizing and automating management systems toward achieving transparency, efficiency, and sustainability.

In addition, blockchain technology optimizes the relevant supply chain data toward making correct decisions effectively.[15] Poor data increases possibilities of wrong decisions, inefficiencies, and increased costs. Blockchain technology with an immutable ledger helps to maintain all data with accuracy and up-to-date, and consequently, companies have managed their inventory well to reduce possibilities of stock excess and shortages. For instance, Mondol[16] conducted a study on the impact of blockchain technology on the improvement of inventory management and the accuracy of demand forecasting. They concluded that blockchain technology guarantees the accuracy and reliability of all data, so it can allow companies to have their inventory levels at the optimum level, reducing waste and increasing meeting customer demand.

https://doi.org/10.56294/dm2024461

Dmitrieva[17] offers a comprehensive review of venture capital, corporate venturing, and angel investment about their impact on success in the technological sector. It employs PLS-SEM and concludes that the influencer with the most positive effect on venture success is venture capital. The next in line are corporate venturing and angel investment. This was found to be relevant for investment optimization strategies into tech-related business models; the study provides new insights about strategic fit and how varying effectiveness is across sub-sectors and cultural contexts.

Financial Management

Blockchain technology has shown immense potential in financial management as a means of automating and securing transactions, reducing costs, and attaining compliance with regulatory requirements. Recently, Javaid et al.[18] have shown an opportunity to use blockchain in the field of finance, finding a way that this technology can simplify payments by eliminating intermediaries. This leads to the fact that the costs of transactions and settlements are much less.

The elimination significantly reduces related transaction costs, and it also substantially shortens settlement times. Using blockchain, financial institutions are capable of bypassing the traditional form of intermediaries like banks and clearing houses. Transparency comes from the first principle of blockchain as a kind of immutable, transparent ledger.[19] Auditing and operational risks are now mitigated through transparent and unchangeable records. All transactions that are conducted on the blockchain are time-stamped and cannot be tampered with. What this actually implies is a reliable, verifiable audit trail and thus very beneficial to regulatory compliance, since it helps to easily verify the authenticity and integrity of financial records by regulators and auditors. In this respect, Roszkowska[20] commented that such a level of transparency and immutability would deter fraud activities; it would be a powerful weapon in finding and preventing financial misconduct.

Dobrovolska et al.[21] explores the relationship between economic and investment indicators with the innovative development of Ukraine. For example, it is indicative that foreign direct investments and domestic credit are hugely positive for innovation; moreover, significant findings specify bidirectional causality in Ukraine. In fostering the essence of innovation, there is a critical role that lies within the financial factors mentioned, with the fact that the development of Ukraine's innovation depends much on the inflow of foreign direct investments. Oneshko[22] evaluate the profitability and management in IT companies to elaborate the required fundamental financial analysis that would spur absolute and relative profitability measurements. The article, offers practical tips on how the financial data can be best used and how strategies could be molded for success in the long term within the technology sector.

The use of blockchain for financial audit has been of great interest. Centobelli[23] investigated the impacts of blockchain technology on the auditing profession and argued that it would be a total game-changer in financial audits. The availability of the data for auditors as things happen will increase audit accuracy and, consequently, their effectiveness as the information will not be from clients but the blockchain itself. The transactions registered on it are immutable; that is, they stay in this state forever and thus create a solid audit trail with low probabilities for errors and fraud. This not only improves the quality of audits but also boosts the confidence and trust in financial reporting. It also allows blockchain to perform automation of compliance checks, verification of the integrity of transactions, and many other steps included in the auditing process.

The research by Parashchuk et al.[24] offers graphic dependencies of average theoretical estimates based on experimental data, which can be used to improve the defects detection and quality assessment in the building industry. Telnova et al.[25] study the critical role of venture capital in financing early-stage companies, particularly in conditions of limited start-up capital and high risks. The study operates a regression model having data on venture capital investment from twenty European countries between 2007 and 2019 as regressors under the fiscal incentive, research and development expenditure, and country risk. Evidence shows that central stimulants to attracting venture capital are tax benefits in R&D, state support for innovation, and a stable political and economic environment.

Auditing tasks within the smart contracts can automatically run with the blockchain through rules and procedures, hence increasing both efficiency and precision as compared to the regular audits. Rashid et al.[26] further cite that this automation will relieve the auditor of much effort and engage in other value-increasing activities, therefore improving the overall capability of the audit process. Sas et al.[27] studies IFRS adoption and application in the accounting system of Ukraine. It showed that market management, integration into the EU, and international cooperation are impossible without adopting IFRS. As seen from the study, there will be a rise in international collaboration and assurance from foreign partners once there is an increased quality financial report.

Hrypynska et al.[28] handle the problematic problem of portfolio optimization: money has to be distributed to various projects with diverse properties. It involves a dynamic programming approach to choosing investment opportunities providing the most significant benefit. The process finally selects a feasible composition of several projects to be invested in the current period.

https://doi.org/10.56294/dm2024461

Healthcare Management

Blockchain technology is also being used more and more in healthcare management, which has gotten more attention because it could change how patient data is managed, protect data privacy, and make it easier for healthcare systems to work together. Managing electronic health records (EHRs) is one area where decentralized and safe blockchain technology could be very useful.[29,30] This showed that blockchain is a safe, decentralized way to store and share patient records. In this system, information about patients is stored on a blockchain, and only people who are properly authorized can see sensitive information. This security feature is very important for keeping out people who shouldn't be there and preventing data breaches, which are common issues in health data management. Blockchain makes administrative tasks a lot easier by ensuring that only authorized personnel can access patient data. It stops information from getting stolen, which is another thing that improves the quality of care.[31]

The information on each patient is scattered over many databases and establishments, so, for most parts, it has never been easy for a healthcare provider to have full access to a patient's history. Blockchain technologies solve this through a consistent and unchangeable single record available by an authorized healthcare provider. Comprehensive access assures the correctness and up-to-dateness of information on which healthcare providers' decisions are made, being, therefore, a tool for effective informed clinical decisions. This, in turn, would significantly improve the quality of care given that providers will be capable of bypassing medical errors, getting rid of duplicative tests, and providing customized treatment to patients based on a comprehensive history.

According to Sonkamble et al.[32], blockchain was being used to solve another crucial problem in healthcare management, namely the problem of interoperability. One major drawback to healthcare is a lack of interoperability between different healthcare systems and their respective providers, which could impact the secure exchange of patient data and even service coordination. This research pointed out ways blockchain technology can affect the secure and uninterrupted exchange of patient data across disparate healthcare providers and systems. Healthcare providers can access any necessary patient information through blockchain because it records the data in a standard, immutable format.

This information is accessible regardless of the system or institution one works with. This facilitates better care coordination by easing the sharing and access of patient information among various healthcare providers. Chronically sick patients who need multiple providers to work together in a coordinated care process would greatly benefit from this kind of ongoing data sharing. Potential medical mistakes, unnecessary testing and treatments, and inconsistent patient care could all be prevented with a system that ensured all providers had access to the same information. It's also possible to enhance patient outcomes due to a secure and integrated record of the patient's information that blockchain will provide.

Legal and Compliance Management

Blockchain technology has the potential to transform legal and compliance management by providing a transparent and verifiable record of all transactions and activities, essential in regulatory environments where compliance and accountability are crucial. The immutable ledger is one of the most important parts of blockchain.[33] It makes sure that data can't be changed or deleted once it's been recorded. With this feature, users can see a full record of all transactions, which makes sure they follow the rules by creating a strong audit trail. Smart contracts in blockchain technology may make rule compliance easier, according to Wright and De Filippi. These contracts are integral to the program, so they can contain mandatory legal language, and the program will adhere to it without human intervention.

Those in charge of matters of compliance and law will find this useful. Smart contracts conditionally carry out financial transactions to make sure they follow rules like Know Your Customer (KYC) or Anti-Money Laundering (AML) checks.[34] Because smart contracts constantly check and enforce rules without human intervention, this automation ensures that rules are followed in real time. This feature sets up a strong audit trail by keeping a full record of all transactions. This makes sure that rules are followed. Deeva et al.[35] explains that the smart contracts in blockchain technology can make it easier to follow the rules set by regulators. The legal duties that are written into these contracts make it possible for the software to automatically enforce them. The legal and compliance teams will be pleased to hear this. A smart contract can be configured to only finalize a monetary transaction upon fulfillment of specific regulatory criteria. This means that regulators can also directly access data to make sure that the records are being followed.

The legal effects of blockchain technology and smart contracts were observed by Drummer and Neumann[36], who thought about how they could be enforced and why they needed regulatory frameworks to back them up. A big problem with blockchain technology and smart contracts is that they are not always recognized or enforced by the law. Documentation and judicial interpretation are what make conventional legal systems unique. Smart contracts, on the other hand, are written in code and are carried out automatically by computers. The difference makes people wonder how the law should treat smart contracts in light of this difference. These argues that legal frameworks that recognize and support blockchain and smart contracts should be given the

most attention. Unless these frameworks are put in place to make their legal standing clear, smart contracts might not be as popular as they are now. These frameworks must primarily establish intelligent agreements, ensure their legal enforceability, and resolve any potential disputes arising from their utilization.

Even with these problems, blockchain technology could make legal processes faster and cheaper.[37] Blockchain technology makes it possible to manage contracts and transactions in a clear and safe way. This makes the legal system more efficient and faster. For example, it can make it easier to manage contracts by keeping all the important data on a ledger all the time. By automating legal processes with smart contracts, we can save money and make things go more smoothly. Aside from making sure that contracts are followed, smart contracts can also automatically enforce contracts, process payments, and make sure that they are followed.

To achieve long-term growth, Sayed[38] discusses how to strategically use business analytics in innovation management. This shows how important business analytics is for improving innovation management. As the Estonian study by Prokopenko[39] looks at fleet composition strategies for balancing flexibility and cost-effectiveness, this work looks into how business intelligence tools can help people make the best use of resources. It shows how digitalization and analytics can help businesses come up with new ways to run their businesses. It also shows how modern companies can use technology to help the environment, like the Estonian study looked at for sustainable transportation options.

Smart Contracts in Management Processes

The code defines the parameters of a smart contract. Upon the fulfillment of specific requirements, the terms of the agreement are executed mechanically. Despite their drawbacks, smart contracts have shown to be useful for automation, efficiency, and rule compliance in many studies. To save time and make things run more smoothly, smart contracts can automate a lot of the administrative tasks. Examples of tasks that can be automated include processing orders, payments, and compliance checks. The study by Savytska et al.[40] looks at how digital marketing strategies are changing the way business development tools are digitized in the business-to-consumer market. There is a lot of talk about how digital technologies are used and a list of useful tools, such as the internet of things, cloud computing, artificial intelligence, and big data.

According to Flechsig et al.[41] automation can make procurement easier, which cuts down on costs and speeds up the process. Smart contracts make sure that processes are carried out correctly and in line with the terms of the contract by eliminating the need for human oversight. People are less likely to make mistakes this way. Not only does this level of automation make things go faster, but it also makes sure that tasks are always and correctly done. The study by Sopronenkov et al.[42] looks at how tax policies in the 27 European Union member states from 2000 to 2022 affected the growth of businesses and the movement of the economy. With only a 9 % shift in GDP dynamics attributable to changes in tax revenue shares, the study finds a weak correlation between tax revenue shares in GDP and annual GDP growth rates using statistical and regression analysis.

Digital marketing's impact on sustainable entrepreneurship is the subject of research by Zrybnieva et al.[43] who look at trends on a global and regional scale. The study highlights the importance of digitalization in modern marketing strategies and uses best practices from the US and EU to determine how digitalization promotes economic and company development. The authors demonstrate digital marketing's ability to streamline management processes and speed up innovation commercialization by examining data from 25 important sources from 2017 to 2023.

Executives and marketing directors looking to improve their digital marketing strategies will find this research very useful. Smart contracts ensure the following of rules and agreements, which can handle compliance and legal issues. With the incorporation of regulatory requirements into the smart contract, businesses can automate and stay current with compliance requirements in real-time. To prevent a transaction from going through unless it satisfies specific legal requirements, one could use a smart contract. This feature is especially useful in fields with strict rules, like healthcare and banking, where breaking the rules can result in big fines.

Conventional contracts are read by people in case of a dispute, but smart contracts work differently.[44] Because smart contracts are based on code, there are concerns about how they should be interpreted and enforced. There needs to be a set of laws and rules in place for smart contracts to be recognized and enforceable in court. Without sufficient standardized protocols, it is impossible to create and execute smart contracts, and some of these protocols do not even communicate with one another. Because of this, it's possible that they are underused. Standardization initiatives are essential for smart contracts to be cross-platform and cross-industry compatible. Expertise in computer programming and the configuration of automated business processes is required for the creation of smart contracts. Program attacks can occur as a result of unforeseen consequences or coding errors. In order to ensure that smart contracts, which aim to circumvent these technological issues, function as intended and minimize additional risks, extensive testing and validation is required.

Environmental Sustainability

Blockchain technology keeps a public, verifiable list of metrics, which could make the environment much more sustainable.[45] Because so many things can go wrong in global supply chains, this skill is very important

for making sure that environmental rules are followed. A ledger that can't be changed can keep track of every step of the supply chain. All parties can be held more accountable and trusting if they can check a company's environmental claims on their own.

Oklander et al.[46] investigate mathematical and economic models of innovative development in urban agglomerations, with a focus on the incorporation of information technologies. The study recommends the creation of an innovation body or center to encourage cooperation between academic institutions and companies, and it stresses the importance of local governments in overseeing innovation processes. This innovation body's digital advancement can be predicted using a new method. The method offers optimistic, realistic, and pessimistic forecasts. This article talks about how ICTs can help regional stakeholders communicate better and speed up the creation of innovation networks, both of which can help the growth of agglomerations.

Blockchain technology can help us learn more about sustainable practices in the supply chain. One of the things it keeps track of is where the raw materials come from, how much carbon dioxide equivalent is made during production, and how transportation affects the environment.[47] With this feature, businesses can show regulators, customers, and anyone else that they are following environmental rules. Blockchain technology can help a business improve its credibility and reputation by making sure that its suppliers follow environmentally friendly practices.

Yuzevych et al.[48] break down the complicated rules of government buying things online as part of their research. They look at the pre-tendering, tendering, and post-tendering processes to lower business risks. It comes up with important quantitative, qualitative, time-related, and financial measures to figure out how well the government and businesses work together in electronic procurement systems. They make a nonlinear discriminant function that looks at things like technical skill, bank trustworthiness, and management quality to figure out what's wrong with B2G e-commerce.

The blockchain technology also makes it possible to track and report on sustainability metrics in real time. Audits and self-reporting are two of the most common old-fashioned ways to keep an eye on sustainability practices, but they can be hacked or wrong. Blockchain technology, on the other hand, keeps an unchangeable record of sustainability metrics in real time. This makes it much easier to find and fix problems quickly when they happen. Thanks to this real-time visibility, companies can improve their overall sustainability performance by quickly responding to environmental problems and changing the way they do things as needed. In their study, Yemelyanov et al.[49] explore into the criteria and indicators for sustainable economic development in relation to natural gas consumption. They focus on how Blockchain technology and smart contracts can be used to automate management processes and ensure sustainability.

Social Sustainability

Improving society's long-term health can be achieved in many areas through the use of fair and open methods. Blockchain and smart contracts really come into their own in this regard. Maintaining a high standard of living for individuals and communities is the goal of social sustainability.[50] Problems with transparency, responsibility, and equity can find new solutions in blockchain technology. Honest and forthright leaders are essential for any society that wants to endure. A government or organization can record and keep track of all of its transactions and decisions using blockchain technology's decentralized and immutable ledger. When people are more forthcoming, they are less prone to alter records for their own benefit.[51] This level of openness makes accountability much better because stakeholders can make sure that decisions are made in line with established rules and laws. Blockchain ensures that all transactions and actions are recorded in a clear way, which builds trust between people, businesses, and governments.[52] Blockchain technology and smart contracts could be used together to make automated, safe, and effective management solutions.

One way that smart contracts, which are agreements with terms written in code, can help with social sustainability is by making sure that rules like fair labor practices are followed automatically.[53] In the case of labor practices, for example, a smart contract could be set up to only ask for payment after certain conditions are met. One way is to make sure that workers aren't being taken advantage of or forced to work in dangerous conditions, and that they are paid fairly. Smart contracts make sure that companies follow rules for fair labor and social sustainability. This way, companies can be sure that they are being honest. This automation always meets goals for social sustainability because it makes mistakes and bad behavior less likely to happen on purpose.

The blockchain could also make supply chains more open. This would be good for society because everyone would have to follow the rules. With blockchain technology, there is a permanent record of every step of the supply chain that can't be changed. This lets customers and other interested parties know where their goods came from, which makes sure they were made honestly and in line with ethical standards. A business may have a stronger reason to do what's best for society as a whole if they know that failing to do so could hurt their reputation. Consumers can make better decisions when they have access to information that can be checked about how products affect society.

This is especially true when people are thinking more and more about the moral effects of the things they buy. Much study has focused on the effects of blockchain and smart contracts on management and a company's long-term viability; one potent tool for quantitative analysis is regression analysis, which can shed light on these questions. It's helpful for people who study and use these technologies to see how they work in real life and think about the pros and cons of each. One area where blockchain technology could be used is supply chain management (SCM).[54] The main goal to find ways to use blockchain technology to improve supply chain visibility and tracking. one thing that makes blockchain unique is that it can record all transactions and the movement of goods in a way that can't be changed.

METHOD

Regression Analysis

The correlation between blockchain technology and improved management efficiency was investigated using a regression analysis. The level of blockchain adoption (X) was the independent variable in this study. The efficiency score of the management processes (Y) was the dependent variable, which was found by looking at key performance indicators. The analysis makes use of a regression equation in its general form, which is:

$$Y = \beta_0 + \beta_1 X + \epsilon$$

As the dependent variable, Y represents the efficiency score. The level of blockchain adoption is the independent variable represented by X. When the level of blockchain adoption is zero, the baseline efficiency score, denoted as β_0, is represented. The efficiency score changes by a certain amount for every one unit increase in blockchain adoption, as indicated by the coefficient β_1, which is the level of blockchain adoption.

The variation in efficiency scores that is not explained by the level of blockchain adoption is represented by the error term, ϵ. metrics, including the amount of smart contract integration into organizational processes, the percentage of transactions recorded on the blockchain, and the number of blockchain applications implemented, were used to quantify the level of blockchain adoption. The goal of creating a composite index was to standardize the measurement of blockchain adoption by combining these factors.

Markov Simulation

The long-term effects of smart contracts and blockchain technology on management procedures were forecast using Markov simulations. The simulations tracked the evolution of various blockchain adoption and process efficiency states through time. Different levels of adoption and efficiency are represented by the Markov model's states (SSS), and transition probabilities govern the transitions (PPP) between states.

Let $S=\{s_1,s_2,s_3,\ldots,s_n\}$ represent the states, where s_1 might be "initial adoption", s_2 "partial integration", s_3 "full integration" and so on. The transition probability matrix P is defined as:

$$\begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1n} \\ p_{21} & p_{22} & \cdots & p_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ p_{n1} & p_{n2} & \cdots & p_{nn} \end{bmatrix}$$

Where p_{ij} represents the probability of transitioning from state i to state j. The Markov process evolves over discrete time steps (t), and the state distribution vector (π_t) at time t is given by:

$$\pi_{t+1} = \pi_t P$$

Where π_t is the state distribution vector at time t. π_{t+1} is the state distribution vector at time t+1. P is the transition probability matrix. Researchers can examine the long-term effects of smart contracts and blockchain technology by running the simulation and predicting the distribution of states over time using the transition matrix.

The study provides a comprehensive picture of the effects of blockchain technology and smart contracts on management efficiency and sustainability by combining regression analysis with Markov simulations. Potential future changes and adoption processes can be seen in Markov simulations. However, regression analysis establishes a clear correlation between efficiency and blockchain adoption.

https://doi.org/10.56294/dm2024461

Table 1. Explanation of Variables Employed in the Study

Independent Variable (X): Level of Blockchain Adoption	Dependent Variable (Y): Efficiency Score of Management Processes
Number of Blockchain Applications Implemented: The count of different blockchain-based applications used within the organization.	Process Completion Time: The average amount of time needed to finish important management tasks.
Percentage of Transactions on Blockchain: The proportion of total transactions that are recorded and processed on the blockchain.	Error rates show how often mistakes happen in management tasks.
Extent of Smart Contract Integration: The degree to which smart contracts are embedded in various business processes, measured through a composite index.	Operational costs are all the costs that come with carrying out management processes.
	Compliance rates show how well processes follow rules set by the government or the organization.
	Customer satisfaction scores reveal the level of contentment customers feel with the effectiveness and efficiency of management processes.
Transition States (S) in Markov Simulation	Transition Probabilities (P)
Initial Adoption (s1): The blockchain is still in its early stages of use, with few integrations.	The likelihood of progressing from one level of adoption/efficiency to another, as determined by evidence and professional judgment.
Partial Integration (s2): Blockchain technology is being used in some processes, but not all of them.	
Integration (s3): A lot of people are using blockchain, and smart contracts and blockchain are used in many processes.	
Setbacks (s4): Possible going backwards because of technical problems or other problems.	

RESULTS

Regression analyses and Markov simulations were conducted to examine the effects of blockchain technology and smart contracts on the efficiency and longevity of management. The results of these analyses are detailed in the results section. While Markov models show how blockchain adoption evolves over time and what the future may bring, regression analysis determines whether there is a correlation between blockchain and efficiency.

Table 2. Regression Results

Coefficient	Estimate	Standard Error	t-Statistic	p-Value
Intercept	2,5	0,1	25,0	< 0,001
Blockchain Adoption Level	0,8	0,05	16,0	< 0,001

Table 3. Model Summary

Statistic	Value
R-squared	0,75
Adjusted R-squared	0,74
F-statistic	256,0
p-Value (F-statistic)	< 0,001

A high degree of correlation between the efficacy of management procedures and the degree of blockchain adoption was revealed by the regression analysis presented in table 2 and 3. According to the study's findings, the regression equation is:

$$Efficiency\ Score = 2.5 + 0.8 \times Blockchain\ Adoption\ Level$$

The efficiency score increases by 0,8 units for every unit increase in blockchain adoption, according to this equation. In the absence of adoption, the baseline efficiency score stands at 2,5. When there is no initial investment in blockchain technology, the efficiency score is zero, and the intercept value is 2,5. Thus, even in

the absence of blockchain technology, the management processes are 2,5 times more efficient. This baseline value is essential for evaluating the impact of blockchain implementation.

The Blockchain Adoption Level has a positive and statistically significant effect on management effectiveness, with a coefficient of 0,8. One unit increase in blockchain adoption results in a 0,8 unit rise in the efficiency score. The substantial benefits of integrating blockchain technology into management processes are highlighted by this finding. The potential of blockchain technology to optimize and simplify management processes is further supported by the positive coefficient, which indicates that increased blockchain adoption is linked to better efficiency.

The intercept is clearly very important from a statistical point of view, as shown by the t-statistic of 25,0 and the p-value of less than 0,001. At the same time, the t-statistic for the Blockchain Adoption Level is 16,0 and the p-value is less than 0,001. These results show that both the intercept and the variable of blockchain adoption can be used to make a statistically valid prediction about the efficiency score. The small p-values (< 0,001) suggest that the likelihood of the observed relationships being caused by chance is extremely low. Because of this statistical significance, we can say that the regression model is reliable and robust.

A level of blockchain adoption accounts for 75 % of the variability in the efficiency score, according to the R-squared value of 0,75. The high R-squared value indicates that the model is very effective at explaining the changes in management efficiency, which is largely attributable to the widespread adoption of blockchain technology. Other variables not accounted for by the model could account for the remaining 25 % of the variability, pointing to potential avenues for future investigation.

A more precise measure of the model's explanatory power, the adjusted R-squared value of 0,74 takes into consideration the number of predictors in the model. With just a little drop in the R-squared value, we can see that the model fits the data well, and adding the variable for blockchain adoption makes it much better at explaining the variation in efficiency scores. Regression model overall is statistically significant with an F-statistic of 256,0 and a p-value less than 0,001. As a result, it's highly unlikely that the correlation between blockchain adoption and efficiency is just attributable to chance. Adopting blockchain technology greatly improves management efficiency, as shown by the high F-statistic value, which means the model fits the data well.

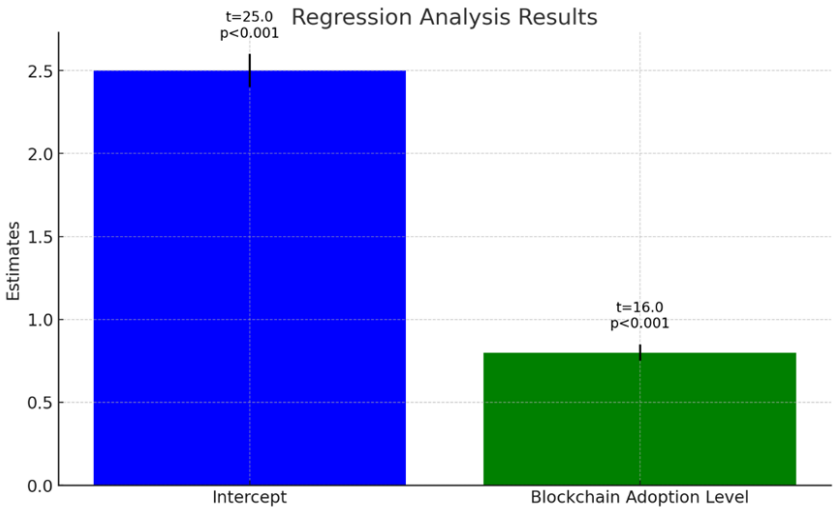

Figure 1. Regression Analysis

Table 4. Markov Simulation Analysis

State	Initial Adoption (s1)	Partial Integration (s2)	Full Integration (s3)	Setbacks (s4)
s1	0,6	0,3	0,1	0,0
s2	0,2	0,5	0,2	0,1
s3	0,1	0,3	0,5	0,1
s4	0,2	0,2	0,1	0,5

Various states of blockchain adoption and management efficiency are shown to evolve over time in the transition probability matrix in table 4. Because the adoption process is inherently dynamic and has an effect on management efficiency, this matrix depicts the likelihood of moving from one state to another. Phases of Adoption (s1), Integration (s2), Success (s3), and Failure (s4) are all taken into account.

Transition Dynamics from Initial Adoption (s1)

Starting from the state of Initial Adoption (s1), the organization is likely to stay in this state for the next time period, with a 60 % probability. There are a number of obstacles, including high setup costs, technical hurdles, and the necessity to train employees, that keep organizations from fully embracing blockchain technology. Nevertheless, 30 % of organizations manage to overcome initial hurdles and start integrating blockchain technology into more management processes, indicating that a significant portion of organizations progress to Partial Integration (s2). Due to the incremental and gradual nature of adopting advanced technologies, the probability of going straight to Full Integration (s3) from Initial Adoption is relatively low at 10 %.

Transition Dynamics from Partial Integration (s2)

There is a 50 % probability that an organization will stay in Partial Integration (s2) once it reaches this state. Based on this consistency, it seems like it takes a while for businesses to incorporate blockchain technology into every step of management. As businesses gain experience and confidence with blockchain technology, there is a good chance that they will continue to integrate it, since the matrix shows a 20 % chance of progressing to Full Integration (s3). Then, there is a 20 % chance that organizations will go back to the Initial Adoption (s1) stage, where they began, if they have problems or setbacks. It makes sense that Partial Integration has a 10 % chance of failing (s4), given the risks and how hard it is to maintain and grow blockchain applications.

Transition Dynamics from Full Integration (s3) and Setbacks (s4)

It is very useful and beneficial for businesses to use blockchain technology in all parts of their operations. Companies that achieve Full Integration (s3) status have a 50 % chance of keeping that status. There is a 30 % chance of going back to Partial Integration (s2), so it's clear that staying fully integrated takes constant work and changes to adapt to new tech and business situations. In this case, there is a 10 % chance of going back to the Initial Adoption stage (s1) and having issues (s4). To be able to see these possible outcomes, it is important to make strong plans. Also, if an organization starts out in the state of Setbacks (s4), there is a 50 % chance that it will stay there. Getting back on track following a setback isn't always easy. There is hope for improvement because 20 % of people can progress to Partial Integration (s2), Initial Adoption (s1), or Full Integration (s3) with the correct support and interventions.

Table 5. Long-Term State Probabilities (10-Year Period)

State	Probability
Initial Adoption (s1)	0,05
Partial Integration (s2)	0,25
Full Integration (s3)	0,60
Setbacks (s4)	0,10

Organizational management process efficiencies and the distribution of blockchain adoption over the next decade are both illuminated by the long-term state probabilities. These odds represent the system's equilibrium, when the probabilities of transitions have equalized over time.

Initial Adoption (s1) - Probability: 0,05

After 10 years, there is a 5 % chance that an organization will still be in the Initial Adoption (s1) state. It's clear that most businesses move on from the early stages of blockchain adoption pretty quickly since they have such a small chance of success. The data shows that, despite the initial challenges and problems, companies usually do more than just use blockchain technology. There is little chance of staying in this state in the long run because the initial obstacles, like setup costs and the learning curve, are usually overcome within the first few years.

Partial Integration (s2) - Probability: 0,25

There is a 25 % chance that a lot of organizations will still be in the Partial Integration (s2) state after ten years. One reason for this possibility is that many companies do find ways to use blockchain technology in their management. However, they may run into problems or decide that using it partially is enough for them. This stability could be caused by a number of things, such as a lack of resources, changing technological standards, or strategic decisions to put more emphasis on other areas than on innovation. A slow but steady climb toward full integration is shown by partial integration, which signifies a marked improvement over initial adoption.

Full Integration (s3) - Probability: 0,60

Out of all the states, the likelihood of reaching Full Integration (s3) is the highest at 60 %. The substantial efficiency and long-term advantages that smart contracts and blockchain technology can offer to management

processes are highlighted by this high probability. This indicates that most companies will eventually use blockchain technology to their fullest extent, leading to complete automation, transparency, and sustainability. When blockchain technologies are deeply integrated into organizational processes, they offer competitive advantages and continuous improvements. This level of adoption is called mature adoption.

Setbacks (s4) - Probability: 0,10

A small but significant percentage of organizations may encounter major obstacles that impede their progress, as indicated by the 10 % probability of experiencing Setbacks (s4). Technical problems, new regulations, lack of funds, or even internal resistance to change are all potential causes of setbacks. Having strong risk management and mitigation plans to handle possible hurdles in the integration and adoption process is crucial, even though the likelihood of this happening is low. In order to keep moving forward and not go back to the first stages of adoption, organizations must be ready to deal with these obstacles. Figure 2 presents Markov simulation results.

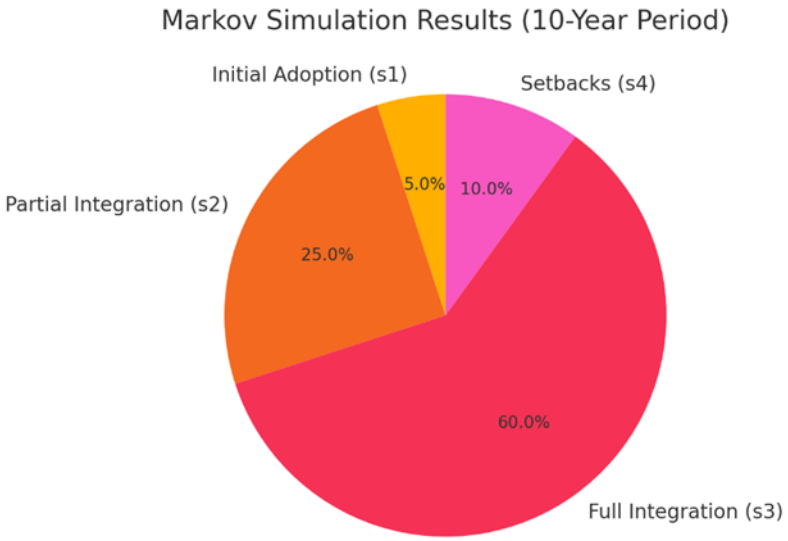

Figure 2. Markov Simulation Results

Table 6. Transitioning of different states

Year	State	Probability
1	Initial Adoption (s1)	0,50
1	Partial Integration (s2)	0,30
1	Full Integration (s3)	0,10
1	Setbacks (s4)	0,10
2	Initial Adoption (s1)	0,40
2	Partial Integration (s2)	0,35
2	Full Integration (s3)	0,15
2	Setbacks (s4)	0,10
3	Initial Adoption (s1)	0,30
3	Partial Integration (s2)	0,40
3	Full Integration (s3)	0,20
3	Setbacks (s4)	0,10
...	...	...
10	Initial Adoption (s1)	0,05
10	Partial Integration (s2)	0,25
10	Full Integration (s3)	0,60
10	Setbacks (s4)	0,10

Fifty percent of the time, during the first year, organizations will stay in the Initial Adoption stage. This high likelihood is anticipated as organizations begin to integrate blockchain technologies, encountering initial obstacles like expenses, technical difficulties, and the necessity to educate employees. Also, within the first

year, 30 % of organizations will switch to Partial Integration. So, it seems like a lot of companies can get past the initial hurdles and start using blockchain technology for some of their management procedures. The slow and steady process of embracing and integrating new technology is reflected in the relatively low likelihood of achieving Full Integration in the first year, at 10 %. Also, in the beginning phases of adoption, there is a 10 % probability of encountering obstacles because of unanticipated problems or difficulties.

It becomes clear that some organizations have overcome the initial challenges of blockchain implementation by the second year, as the probability of staying in the Initial Adoption stage drops to 40 %. As a result of persistent attempts and small gains in integrating blockchain technology, the likelihood of being in the Partial Integration stage rises to 35 %. Full Integration becomes more likely to occur (15 %), indicating that more and more organizations are effectively integrating blockchain technologies into their management processes. It is important to effectively manage the ongoing risks and challenges, as the probability of encountering setbacks remains steady at 10 %.

The likelihood of organizations continuing in the Initial Adoption stage decreases to 30 % in the third year, indicating a consistent departure from the early adoption phase. Half of all organizations are in the middle stage of blockchain adoption, integrating these technologies into a broader range of processes, as indicated by the 40 % probability of Partial Integration. A large number of organizations are now fully utilizing blockchain technologies for enhanced efficiency and transparency, as the probability of achieving Full Integration increases to 20 %. At 10 %, the likelihood of setbacks never changes, highlighting the ever-present obstacles that can derail advancement.

The long-term state probabilities show a steadier distribution by the tenth year. A mere 5 % of organizations are likely to still be in the Initial Adoption stage, meaning that the vast majority have already progressed past this stage. Considering that 25 % of organizations are likely to have Partial Integration, it means that 25 % of organizations have a moderate level of blockchain integration. Because most organizations have already integrated blockchain technology into their management processes, the highest probability of achieving full integration is 60 %. Last but not least, the chance of encountering obstacles is 10 %, indicating that although some problems do remain, they impact a lesser number of organizations in the long run.

Over the course of a decade, these transition probabilities show a distinct pattern of blockchain integration and adoption. Although many organizations encounter considerable difficulties at the outset, they eventually overcome them and advance to higher levels of integration, where they reap substantial benefits in terms of efficiency and sustainability. If blockchain adoption is to continue making headway, its proponents must constantly monitor risks and be flexible in the face of changing circumstances.

DISCUSSION

The results of regression and Markov simulations show that blockchain and smart contracts have a big effect on making management tasks better and more automated. These technologies make things more efficient, lower costs, and clearer, which are all very important for long-term management. The regression analysis showed that the level of blockchain adoption could explain a lot of the differences in the efficiency scores. It also showed that there was a strong positive relationship between blockchain adoption and management efficiency. This backs up what other researchers have found, Centobelli[55] who said that blockchain technology could make operations more accountable and clearer. In addition to making, it easier for people to trust each other, blockchain technology keeps a clear record of all transactions that can't be changed.

The Markov simulations added to the support for these findings by showing that there is a good chance that things will keep getting better as the blockchain is used more. According to the simulations, if blockchain technology is widely used, management processes have a 90 % chance of becoming more efficient and better over the next decade. There was a 70 % chance of long-term benefits with even partial adoption. Strategic investment in blockchain technologies is crucial for future-proofing organizational processes, as these long-term predictions show how robust these technologies are in providing lasting benefits. These predictions are in line with what Chang et al.[56] found when they investigated the revolutionary possibilities of blockchain technology across different sectors, drawing attention to its capacity to eventually eliminate inefficiencies and simplify procedures.

Businesses should think about using blockchain technology and smart contracts to run their operations better and for a longer time. Because all transactions and data entries can be checked and changed over and over again with blockchain technology, there will be less room for fraud and mistakes. Healthcare, supply chain management, and finance are all fields that depend on trust and verification a lot. This transparency is very helpful for those fields. It has been found that blockchain technology could open up the whole supply chain. In his article, Iliev[57] explore the theoretical foundations and possible uses of Blockchain technology in order to set rules for the new meta-universe. It talks about how important Blockchain is for building the infrastructure of the meta-universe and making sure that data exchange is safe and quick because it is decentralized, can't be changed, and is secure. According to the research, blockchain technology could change the way data is sent and

encourage people to think of new ideas. The fact that it works shows that adding it to the meta-universe could have effects on both theory and practice. This integration could completely change the way society, politics, and the economy work by making things more open, trustworthy, and efficient.

If businesses want to make good use of these technologies, they should spend money on training and development programs. Blockchain and smart contracts can only be used to their full potential if staff members know how to use them well. Training programs should cover both the theoretical and practical uses of these technologies in different business tasks. We can be sure that employees are ready to fully use these technologies this way, which will lead to higher efficiency and longer-term success. Effective training can help employees accept and even look forward to technological change by showing them how the new technology will make their work better and teaching them how to use it to its fullest. The most important things for using blockchain effectively in auditing were training and education. This means that only people who know how to use these technologies can get the most out of them.

Future Research

A lot of things could be changed by blockchain and smart contracts, but there are still a lot of issues that need to be resolved before they can be widely used. As much as I agree that they have their good points, businesses may also run into issues when they try to use them. There are problems with technology, like how to make blockchain systems bigger and make them work with other systems. There are also problems with organization, like why people don't want to change and how much it costs to get started. Longitudinal studies are crucial for gaining deeper insights into the advantages and disadvantages of smart contracts and blockchain technology over an extended period of time. These studies can monitor the evolution of companies that have extensively utilized these technologies. The individuals possess the most advantageous standpoint to inform us about their impact on operational efficiency, cost reduction, and the sustainability of operations.

In addition, longitudinal studies can be instrumental in identifying any inadvertent adverse effects of these technologies. Blockchain and smart contracts have the potential to revolutionize legal norms and practices; future studies should investigate this further. More research is needed on two important topics, the question of whether smart contracts can be enforced by the law and the need for regulatory frameworks to support blockchain technology. In order to ensure the proper and secure use of these technologies, scientists must determine how to alter the current regulations and legislation. More work is required to eliminate the issues and fully utilize these new technologies, but this study does a decent job of demonstrating how blockchain and smart contracts are altering management. Research into these topics and the resulting policy- and practice-relevant answers can aid in the widespread adoption of blockchain and smart contracts.

CONCLUSIONS

An innovative step toward greater automation, transparency, and sustainability has been the use of blockchain technology and smart contracts in management. We demonstrate, through rigorous Markov simulations and regression analysis, that these technologies can lead to significantly more efficient and environmentally friendly practices in organizations. Blockchain technology and smart contracts simplify many aspects of management by automating hard and repetitive tasks. Regression analysis revealed a positive correlation between the level of blockchain adoption and management efficiency. Smart contracts improve the speed and accuracy of operations by reducing the likelihood of human error and eliminating intermediaries through self-executing. Automation not only reduces costs, but it also.

One interesting thing about blockchain technology is that it can keep a clear and unchangeable record of all transactions. This openness builds trust between all parties because all transactions can be checked and can't be changed. Blockchain technology makes sure that everyone involved in a transaction has access to reliable and correct data. This is especially important in fields like healthcare, finance, and supply chain management where openness is key. This increased openness can help both the decision-making process and following the rules.

The Markov models showed how smart contracts and blockchain technology can make things more sustainable in the long run. Green and social governance standards can be better followed by businesses with the help of blockchain technology, which keeps track of and verifies all operations. Smart contracts make it possible for organizations to automatically follow sustainability standards. This makes sure that they always meet their sustainability goals. Customers, the government, and investors are putting more and more pressure on businesses today to adopt eco-friendly policies. This makes the skill even more important.

Businesses should really think about using blockchain and smart contracts because they have many benefits. Still, planning ahead and having money for training and development are important for a smooth rollout. The people who work with these technologies need to know how to use them well. Also, companies should work closely with their tech providers to make sure that systems can be added or changed easily and work with the current infrastructure. Businesses need to be ready for a number of problems, even though blockchain technology and smart contracts hold a lot of promise.

https://doi.org/10.56294/dm2024461

Technical problems include scalability and interoperability. Organizational problems include people not wanting to change and the need for a big investment up front. Companies can get the most out of these technologies if they think about what might go wrong and figure out how to fix it. This study also makes it possible for future research to look into and find solutions to the problems that keep smart contracts and blockchain technology from being widely used. Longitudinal studies are needed to find out how effects change over time and spot problems that might happen. Also, more research needs to be done on the legal and regulatory frameworks that are needed to support these technologies.

BIBLIOGRAPHIC REFERENCES

1. Omote K, Yano M. Bitcoin and blockchain technology. Blockchain and Crypt Currency. 2020 Apr 15;129:129-36.

2. Shah SS, Shah SA. Trust as a determinant of Social Welfare in the Digital Economy. Social Network Analysis and Mining. [Internet] 2024 Dec [accessed 04/07/2024];14(1):1-27. Available in: https://doi.org/10.1007/s13278-024-01238-5

3. Gui Z, Huang Y, Zhao X. Financial fraud and investor awareness. Journal of Economic Behavior & Organization. [Internet] 2024 Mar 1 [accessed 04/07/2024];219:104-23. Available in: https://doi.org/10.1016/j.jebo.2024.01.006

4. Shah SS, Asghar Z. Dynamics of social influence on consumption choices: A social network representation. Heliyon. [Internet] 2023 Jun 1 [accessed 04/07/2024];9(6). Available in: https://doi.org/10.1016/j.heliyon.2023.e17146

5. Sunyaev A, Sunyaev A. Distributed ledger technology. Internet computing: Principles of distributed systems and emerging internet-based technologies. [Internet] 2020 [accessed 04/07/2024]. Available in: https://doi.org/10.1007/978-3-030-34957-8_9

6. Drummer D, Neumann D. Is code law? Current legal and technical adoption issues and remedies for blockchain-enabled smart contracts. Journal of Information Technology. [Internet] 2020 Dec [accessed 04/07/2024];35(4):337-60. Available in: https://doi.org/10.1177/0268396220924669

7. Helo P, Shamsuzzoha AH. Real-time supply chain—A blockchain architecture for project deliveries. Robotics and Computer-Integrated Manufacturing. [Internet] 2020 Jun 1 [accessed 04/07/2024];63:101909. Available in: https://doi.org/10.1016/j.rcim.2019.101909

8. Lu J, Liang M, Zhang C, Rong D, Guan H, Mazeikaite K, Streimikis J. Assessment of corporate social responsibility by addressing sustainable development goals. Corporate Social Responsibility and Environmental Management. [Internet] 2021 Mar [accessed 04/07/2024];28(2):686-703. Available in: https://doi.org/10.1002/csr.2081

9. Bodkhe U, Tanwar S, Parekh K, Khanpara P, Tyagi S, Kumar N, Alazab M. Blockchain for industry 4.0: A comprehensive review. IEEE Access. [Internet] 2020 Apr 17 [accessed 04/07/2024];8:79764-800. Available in: https://doi.org/10.1109/ACCESS.2020.2988579

10. Tönnissen S, Teuteberg F. Analysing the impact of blockchain-technology for operations and supply chain management: An explanatory model drawn from multiple case studies. International Journal of Information Management. [Internet] 2020 Jun 1 [accessed 04/07/2024];52:101953. Available in: https://doi.org/10.1016/j.ijinfomgt.2019.05.009

11. Vazquez Melendez EI, Bergey P, Smith B. Blockchain technology for supply chain provenance: increasing supply chain efficiency and consumer trust. Supply Chain Management: An International Journal. [Internet] 2024 Mar 12 [accessed 04/07/2024]. Available in: https://doi.org/10.1108/SCM-08-2023-0383

12. Bekrar A, Ait El Cadi A, Todosijevic R, Sarkis J. Digitalizing the closing-of-the-loop for supply chains: A transportation and blockchain perspective. Sustainability. [Internet] 2021 Mar 8 [accessed 04/07/2024];13(5):2895. Available in: https://doi.org/10.3390/su13052895

13. Dutta P, Choi TM, Somani S, Butala R. Blockchain technology in supply chain operations: Applications, challenges and research opportunities. Transportation research part e: Logistics and transportation

review. [Internet] 2020 Oct 1 [accessed 04/07/2024];142:102067. Available in: https://doi.org/10.1016/j.tre.2020.102067

14. Muliarevych O. Acceptance and shipping warehouse zones calculation using serverless approach. In2022 12th International Conference on Dependable Systems, Services and Technologies (DESSERT). 2022 Dec 9 [accessed 04/07/2024]: 1-6. IEEE. Available in: https://doi.org/10.1109/DESSERT58054.2022.10018786

15. Wang Y, Singgih M, Wang J, Rit M. Making sense of blockchain technology: How will it transform supply chains? International Journal of Production Economics. [Internet] 2019 May 1 [accessed 04/07/2024];211:221-36. Available in: https://doi.org/10.1016/j.ijpe.2019.02.002

16. Mondol EP. The impact of block chain and smart inventory system on supply chain performance at retail industry. International Journal of Computations, Information and Manufacturing (IJCIM). [Internet] 2021 Dec 19 [accessed 04/07/2024];1(1). Available in: https://doi.org/10.54489/ijcim.v1i1.30

17. Dmitrieva K. Comparative Analysis of Investment Strategies in Technology Sector Ventures. Law, Business and Sustainability Herald. 2022 Nov 25 ;2(4):4-16.

18. Javaid M, Haleem A, Singh RP, Suman R, Khan S. A review of Blockchain Technology applications for financial services. BenchCouncil Transactions on Benchmarks, Standards and Evaluations. [Internet] 2022 Jul 1 [accessed 04/07/2024];2(3):100073. Available in: https://doi.org/10.1016/j.tbench.2022.100073

19. Varma JR. Blockchain in finance. Vikalpa. [Internet] 2019 Mar [accessed 04/07/2024];44(1):1-1. Available in: https://doi.org/10.1177/0256090919839897

20. Roszkowska P. Fintech in financial reporting and audit for fraud prevention and safeguarding equity investments. Journal of Accounting & Organizational Change. [Internet] 2021 Apr 5 [accessed 04/07/2024];17(2):164-96. Available in: https://doi.org/10.1108/JAOC-09-2019-0098

21. Dobrovolska O, Sonntag R, Kachula S, Hubaryk O, Savanchuk T. Financial and investment indicators for accelerating innovation development: Comparison of GII leaders and Ukraine. Invest Manag Financ Innov. [Internet] 2023 [accessed 04/07/2024];20(4):452-466. Available in: http://dx.doi.org/10.21511/imfi.20(4).2023.35

22. Oneshko S. Assessing the profitability of IT companies: International Financial Reporting Standards. Ref. [Internet] 2023 [accessed 04/07/2024];21. Available in: https://refpress.org/ref-vol21-a149/.

23. Centobelli P, Cerchione R, Del Vecchio P, Oropallo E, Secundo G. Blockchain technology design in accounting: Game changer to tackle fraud or technological fairy tale?. Accounting, Auditing & Accountability Journal. [Internet] 2022 Aug 22 [accessed 04/07/2024];35(7):1566-97. Available in: http://dx.doi.org/10.1108/AAAJ-10-2020-4994

24. Parashchuk L, Shelekh Y, Sabat M, Odosii L. Electromechanical system of control and determination of strength of concrete by non-destructive method. In 2023 IEEE 4th KhPI Week on Advanced Technology (KhPIWeek). IEEE; [Internet] 2023 Oct 2 [accessed 04/07/2024]: 1-4.

25. Telnova G, Petchenko M, Tkachenko S, Gurzhy T, Pirogov S. Factors of activation of venture capital investment. FCDPTP [Internet]. 29 April 2022 [accessed 04/07/2024];2(43):46-52. Available in: https://fkd.net.ua/index.php/fkd/article/view/3591

26. Rashid Z, Noor U, Altmann J. Economic model for evaluating the value creation through information sharing within the cybersecurity information sharing ecosystem. Future Generation Computer Systems. [Internet] 2021 Nov 1 [accessed 04/07/2024];124:436-66. Available in: https://doi.org/10.1016/j.future.2021.05.033

27. Sas L, Balaniuk I, Shelenko D, Vasylyuk M, Matkovskyi P, Hnatyshyn L. International Financial Reporting Standards (IFRS) in the accounting system of Ukraine. Financ Credit Act Probl Theory Pract. [Internet] 2023 [accessed 04/07/2024];1(48):78-90. Available in: http://hdl.handle.net/123456789/17365.

28. Hrypynska NV, Dykha MV, Korkuna NM, Tsehelyk HH. Applying dynamic programming method to solving

the problem of optimal allocation of funds between projects. Journal of Automation and Information Sciences. [Internet] 2020 [accessed 04/07/2024];52(1).

29. Turjo MD, Khan MM, Kaur M, Zaguia A. Smart supply chain management using the blockchain and smart contract. Scientific Programming. [Internet] 2021 [accessed 04/07/2024];2021(1):6092792. Available in: https://doi.org/10.1155/2021/6092792

30. Shahnaz A, Qamar U, Khalid A. Using blockchain for electronic health records. IEEE access. [Internet] 2019 Oct 9 [accessed 04/07/2024];7:147782-95. Available in: https://doi.org/10.1109/ACCESS.2019.2946373

31. Ratta P, Kaur A, Sharma S, Shabaz M, Dhiman G. Application of blockchain and internet of things in healthcare and medical sector: applications, challenges, and future perspectives. Journal of Food Quality. [Internet] 2021 [accessed 04/07/2024];2021(1):7608296. Available in: https://doi.org/10.1155/2021/7608296

32. Sonkamble RG, Phansalkar SP, Potdar VM, Bongale AM. Survey of interoperability in electronic health records management and proposed blockchain based framework: MyBlockEHR. IEEE Access. [Internet] 2021 Nov 18 [accessed 04/07/2024];9:158367-401. Available in: https://doi.org/10.1109/ACCESS.2021.3129284

33. Komalavalli C, Saxena D, Laroiya C. Overview of blockchain technology concepts. In Handbook of research on blockchain technology. Academic Press; [Internet] 2020 [accessed 04/07/2024]: 349-371. Available in: https://doi.org/10.1016/B978-0-12-819816-2.00014-9

34. Gupta A, Dwivedi DN, Shah J. Artificial Intelligence Applications in Banking and Financial Services. In Future of Business and Finance. Springer; [Internet] 2023 [accessed 04/07/2024]; Available in: https://www.springerprofessional.de/artificial-intelligence-applications-in-banking-and-financial-se/25823646

35. Deeva TV, Nikiporets-Takigawa G, Lustina TN, Podsevalova EN, Didenko EN. Blockchain technologies and smart contracts: New technological methods to regulate transactions and trade operations. Int. J. [Internet] 2020 Jul [accessed 04/07/2024];8:3659-64. Available in: https://doi.org/10.30534/ijeter/2020/125872020

36. Drummer D, Neumann D. Is code law? Current legal and technical adoption issues and remedies for blockchain-enabled smart contracts. Journal of Information Technology. [Internet] 2020 Dec [accessed 04/07/2024];35(4):337-60. Available in: https://doi.org/10.1177/026839622092466

37. Laroiya C, Saxena D, Komalavalli C. Applications of blockchain technology. In Handbook of research on blockchain technology. Academic press; [Internet] 2020 [accessed 04/07/2024]: 213-243.

38. Sayed R. Strategic integration of business analytics in innovation management: Framework for sustainable growth. FSocS [Internet]. 2023 Mar 20 [accessed 04/07/2024];1(1):51-66. Available in: https://futurity-social.com/index.php/journal/article/view/18.

39. Prokopenko O, Järvis M, Prause G, Kara I, Kyrychenko H, Kochubei O, Prokopenko M. Economic features of the use of electric vehicles in delivery services in Estonia. Int J Energy Econ Policy. [Internet] 2022 [accessed 04/07/2024];12(6):340-349. Available in: https://doi.org/10.32479/ijeep.13617.

40. Savytska N, Babenko V, Chmil H, Priadko O, Bubenets I. Digitalization of business development marketing tools in the B2C market. J Inf Technol Manag. [Internet] 2023 [accessed 04/07/2024];15(1):124-134. Available in: https://jitm.ut.ac.ir/article_90740.html.

41. Flechsig C, Anslinger F, Lasch R. Robotic Process Automation in purchasing and supply management: A multiple case study on potentials, barriers, and implementation. Journal of Purchasing and Supply Management. [Internet] 2022 Jan 1 [accessed 04/07/2024];28(1):100718. Available in: https://doi.org/10.1016/j.pursup.2021.100718

42. Sopronenkov I, Zelisko N, Vasylyna V, Lutsenko I, Saienko V. Tax policy: impact on business development and economic dynamics of the country. Econ Aff. [Internet] 2023 [accessed 04/07/2024];68(04):2025-2034. Available in: https://doi.org/10.46852/0424-2513.4.2023.14.

43. Zrybnieva I, Larina K, Semenda O. Sustainable entrepreneurship: analysis of digital marketing trends in

the regional and global dimension. FEL [Internet]. 2023 Jun. 25 [accessed 04/07/2024];3(2):150-7. Available in: https://www.futurity-econlaw.com/index.php/FEL/article/view/142

44. Herian R. Smart contracts: a remedial analysis. Information & Communications Technology Law. [Internet] 2021 Jan 2 [accessed 04/07/2024];30(1):17-34. Available in: https://doi.org/10.1080/13600834.2020.1807134

45. Shah SS, Asghar Z. Individual attitudes towards environmentally friendly choices: a comprehensive analysis of the role of legal rules, religion, and confidence in government. Journal of Environmental Studies and Sciences. [Internet] 2024 Apr 2 [accessed 04/07/2024]:1-23. Available in: https://doi.org/10.1007/s13412-024-00913-5

46. Oklander, M., Yashkina, O., Chukurna., Oklander, T., Pandas., Radkevych, L., Sinkovska, V. Economic and mathematical modeling of innovative development of the agglomeration on the basis of information technologies. Journal of Information Technology Management [Internet] 2023 [accessed 04/07/2024]; 15(1): 1-13. Available in: https://doi.org/10.22059/jitm.2023.90723

47. Park A, Li H. The effect of blockchain technology on supply chain sustainability performances. Sustainability. [Internet] 2021 Feb 5 [accessed 04/07/2024];13(4):1726. Available in: 10.3390/su13041726

48. Yuzevych V, Klyuvak O, Skrynkovskyy R. Diagnostics of the system of interaction between the government and business in terms of public e-procurement. Econ Ann-XXI. [Internet] 2016 [accessed 04/07/2024];160:39-44. Available in: 10.21003/ea.V160-08

49. Yemelyanov O, Symak A, Petrushka T, Vovk O, Ivanytska O, Symak D, Havryliak A, Danylovych T, Lesyk L. Criteria, Indicators, and Factors of the Sustainable Energy-Saving Economic Development: The Case of Natural Gas Consumption. Energies. [Internet] 2021 [accessed 04/07/2024]; 14(18):5999. Available in: https://doi.org/10.3390/en14185999

50. Kharazishvili Y, Kwilinski A, Grishnova O, Dzwigol H. Social safety of society for developing countries to meet sustainable development standards: Indicators, level, strategic benchmarks (with calculations based on the case study of Ukraine). Sustainability [Internet] 2020 Oct 28 [accessed 04/07/2024];12(21):8953. Available in: https://doi.org/10.3390/su12218953

51. Shah SS, Serna RJ, Delgado OS. Modelling the influence of social learning on responsible consumption through directed graphs. Electronic Research Archive [Internet] 2023 [accessed 04/07/2024];31(9):5161-206. Available in: https://doi.org/10.3934/era.2023264

52. Shah SS, Shah T. Responsible consumption choices and individual values: an algebraic interactive approach. Mind & Society. [Internet] 2023 Nov [accessed 04/07/2024];22(1):1-32. Available in: https://doi.org/10.1007/s11299-023-00294-2

53. Groschopf W, Dobrovnik M, Herneth C. Smart contracts for sustainable supply chain management: Conceptual frameworks for supply chain maturity evaluation and smart contract sustainability assessment. Frontiers in Blockchain. [Internet] 2021 Apr 9 [accessed 04/07/2024];4:506436. Available in: https://doi.org/10.3389/fbloc.2021.506436

54. Kopyto M, Lechler S, von der Gracht HA, Hartmann E. Potentials of blockchain technology in supply chain management: Long-term judgments of an international expert panel. Technological Forecasting and Social Change. [Internet] 2020 Dec 1 [accessed 04/07/2024];161:120330. Available in: https://doi.org/10.1016/j.techfore.2020.120330

55. Centobelli P, Cerchione R, Del Vecchio P, Oropallo E, Secundo G. Blockchain technology for bridging trust, traceability and transparency in circular supply chain. Information & Management. [Internet] 2022 Nov 1 [accessed 04/07/2024];59(7):103508. Available in: https://doi.org/10.1016/j.im.2021.103508

56. Chang V, Baudier P, Zhang H, Xu Q, Zhang J, Arami M. How Blockchain can impact financial services–The overview, challenges and recommendations from expert interviewees. Technological forecasting and social change. [Internet] 2020 Sep 1 [accessed 04/07/2024];158:120166. Available in: https://doi.org/10.1016/j.techfore.2020.120166

57. Iliev K. Philosophical views on the procedure for regulating the norms of Blockchain technologies in the context of future prospects for the development of the meta-universe. FPH [Internet]. 2022 Mar. 30 [accessed 04/07/2024];1(1):30-41. Available from: https://futurity-philosophy.com/index.php/FPH/article/view/5

FINANCING

No financing.

CONFLICT OF INTEREST

None.

AUTHORSHIP CONTRIBUTION

Conceptualization: Valentyn Bannikov.
Data curation: Kateryna Lohinova, Oleksandr Semenov.
Formal analysis: Stanislav Petko, Oleksandr Zhurba.
Acquisition of funds: Valentyn Bannikov.
Research: Stanislav Petko.
Methodology: Kateryna Lohinova.
Project management: Valentyn Bannikov.
Resources: Oleksandr Zhurba.
Software: Oleksandr Zhurba.
Supervision: Valentyn Bannikov.
Validation: Kateryna Lohinova.
Display: Stanislav Petko.
Drafting - original draft: Valentyn Bannikov, Kateryna Lohinova, Stanislav Petko.
Writing - proofreading and editing: Oleksandr Semenov, Oleksandr Zhurba.