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The convergence of artificial intelligence, blockchain and fintech in energy, oil and gas trading: Increasing efficiency, transparency and automations

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Abstract

Artificial intelligence (AI) and blockchain technology, in conjunction with Financial Technology (Fintech), are playing an increasingly significant role in shaping global Energy Trading trends. The combined use of blockchain, AI, and Fintech introduces innovative features that have the potential to improve the efficiency and performance of current systems. This study provides insights into the key features of the intersection of AI, blockchain, and Fintech, such as data security, encryption, sharing, efficiency, collective decision-making, decentralized intelligent systems, transparency, automated decision systems, and financial applications. By analyzing literature from major digital databases, this technological convergence was constructed via the emerging era, convergence era and application era. In the convergence era, features were categorized into data manipulation, regulations, applicability to legacy systems, compatibility and hardware issues. The application era explores the impact of this technology fusion in areas like cybersecurity, finance, energy, Internet of Things applications, and smart cities. This comprehensive analysis helps outline the timeline of AI, blockchain, and Fintech convergence and highlights the unique characteristics of their integration. The paper concludes by addressing the current challenges and how it is increasing efficiency, transparency and automation of AI, blockchain, and Fintech in energy trading and also in the sector of energy trading i.e. electricity, gas, oil and non renewable energies. AI enables predictive analytics and automation, blockchain ensures secure and transparent transactions, and FinTech facilitates seamless financial transactions and risk management in energy trading. The convergence revolutionizes energy trading.

Keywords: AI; Blockchain; Fintech; Convergence; Efficiency; Transparency and automation

1. Introduction

Artificial Intelligence or AI, refers to the simulation of human intelligence processes by machines, typically computer systems. These processes include learning, reasoning, problem-solving, perception, and language understanding. AI technologies enable machines to perform tasks that typically require human intelligence, such as visual perception, speech recognition, decision-making, and language translation. AI systems can adapt and improve their performance over time through learning from data and experiences, making them increasingly valuable in various fields, including healthcare, finance, transportation, and more.

Blockchain is a revolutionary technology that provides a decentralized and secure way to record transactions. It has transformed the financial landscape by enabling the rise of cryptocurrencies and smart contracts, changing the way financial transactions are executed. The key features of blockchain include decentralization, transparency, immutability, and enhanced security. Transactions on the blockchain are verified by multiple participants in a peer-to-peer network, eliminating the need for intermediaries and enhancing security. The transparency and immutability of blockchain data build trust and reliability in financial transactions. Cryptocurrencies and smart contracts leverage blockchain

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technology to offer efficient and cost-effective ways to conduct transactions without relying on traditional banking systems. Smart contracts are self-executing agreements written in code, automating processes and reducing the need for intermediaries. Blockchain technology has the potential to disrupt traditional financial systems and revolutionize the way transactions are conducted, offering a new level of trust, transparency, and efficiency in financial transactions.

Fintech, short for financial technology, comprises cutting-edge digital solutions and technologies that transform and elevate the conventional financial sector. It encompasses diverse applications such as mobile banking, peer-to-peer lending, blockchain-based cryptocurrencies, robo-advisors, and payment processing. Fintech harnesses the progress in data analytics, artificial intelligence, and secure online platforms to simplify financial transactions, lower expenses, and enhance accessibility for individuals and enterprises. This evolution in the financial realm provides convenience, effectiveness, and increased financial participation, influencing how individuals handle, invest, and conduct financial transactions in today's digital era.

“FinEntech refers to digital innovations that are at the intersection of finance and energy. Energy companies typically run four parallel macro processes where fintech intersects with energy: The capital processes of building new infrastructure (design, build, commission, handover), The operational processes of producing and distributing energy using that infrastructure (fuel sourcing, asset operation, measurement), The operational processes of maintaining that infrastructure (scheduling and permitting, work orders, testing, safety), and The commercial processes for accessing capital (sourcing cash) billing for energy products (collecting cash) and payments for capital and maintenance (spending cash).” Mentioned By Geoffrey Cann at TCU Energy Institute, sourced from <https://energynow.ca/2021/10/energy-technology-meets-fintech-please-pay-attention/>

The convergence of these advanced technologies has inaugurated a new era, fundamentally transforming the landscape of energy payments in terms of conception, delivery, and user experience. Through avenues such as Digital Payments, Online Lending, Robo-Advisors, Blockchain, Cryptocurrency, and Regtech, FinTech is reshaping how individuals manage their finances in the contemporary world. The disruptive nature of FinTech has challenged traditional payment models, fostering an environment of innovation and competition while revolutionizing customer experiences and operational frameworks within energy institutions.

The integration of AI and blockchain was first explored in 2014 and 2015, but initial efforts were limited and unclear. A more comprehensive exploration of this fusion occurred in the years 2018-2023, with publications suggesting that cryptocurrencies and smart contracts could enhance the positive impact of AI on society. While traditional smart contracts are effective for digital transactions, challenges arise when dealing with real-world interactions, requiring additional intelligence. AI systems are essential for translating sensor data into a format understandable by smart contracts, especially for interactions beyond digital transactions. To interact with the physical world, such as triggering object deliveries, a more sophisticated approach linking smart contracts to human or robotic agents is necessary.

Experiments have shown that blockchain technology can serve as a framework for databases, facilitating increased sharing of personal data for training AI algorithms. This data is crucial for improving AI systems and reflects the growing concerns around security vulnerabilities, exploitation, cyberattacks, robustness, and sustainability in an evolving environment focused on the well-being of human societies.

The convergence of AI, blockchain, and Fintech in energy trading is revolutionizing the industry by increasing efficiency, transparency, and automation in several ways:

- **Efficiency:** AI algorithms can analyze vast amounts of data in real-time to identify trading opportunities, optimize trading strategies, and execute trades more efficiently. This can help energy traders make faster and more informed decisions, leading to improved profitability and reduced operational costs.
- **Transparency:** Blockchain technology provides a secure and transparent way to record and verify transactions in real-time. By using blockchain in energy trading, participants can have a tamper-proof and auditable record of all transactions, ensuring transparency and trust among market participants. This can help reduce the risk of fraud and improve regulatory compliance.
- **Automation:** Fintech tools, such as automated trading platforms and smart contracts, can help automate the trading process and reduce the need for manual intervention. Smart contracts, which are self-executing contracts with the terms of the agreement directly written into code, can automate trade settlements, reduce transaction times, and minimize the risk of errors. This automation can streamline operations, increase trading volumes, and improve overall efficiency.

Overall, the convergence of AI, blockchain, and Fintech in energy trading is transforming the industry by enabling faster, more efficient, and transparent trading processes. Market participants can leverage these technologies to gain a competitive edge, reduce costs, and enhance risk management in the dynamic energy markets.

By leveraging the convergence of AI, blockchain, and Fintech in energy trading, market participants in the oil, gas, and electricity sectors can gain a competitive edge, increase trading volumes, and enhance risk management. These technologies enable faster, more efficient, and transparent trading processes, ultimately driving innovation and transformation in the energy trading sector.

2. Background of the study

Previous research in this field has consistently highlighted the potential of combining blockchain, AI, and fintech as instrumental tools to enhance the efficiency of various business, organizational, and industrial operations. The widespread adoption of AI and blockchain technologies across diverse objectives and fields underscores their versatility and broad applicability. For example, in transportation systems, integrating blockchain for smart vehicles can enhance the security and privacy of intelligent vehicle ecosystems. Similarly, the integration of blockchain and AI is prevalent in healthcare, where it improves data analysis and information flow, while also ensuring the safeguarding of personal data and empowering users with control over their identifiable information. This practical application demonstrates the tangible benefits of combining AI, blockchain, and fintech in real-world settings, benefiting business units by enhancing market processes and facilitating secure communication with diverse customers. Recent advancements in the Internet of Things (IoT) and blockchain technology have led to the development of hybrid models incorporating various classification schemes. While challenges exist in integrating blockchain, AI, and IoT into a cohesive system, including security, scalability, accountability, and trustworthiness of communications, the successful integration of these domains is seen as a catalyst for developing new business models and digitally transforming market corporations. Real-world deployment and success stories illustrate that active adoption and integration into operational frameworks are essential for realizing the potential benefits of this combined technology approach.

The energy, oil, and gas sectors play a crucial role in powering economies and societies worldwide. These industries have a history of embracing technological advancements, and in recent years, the rise of financial technology, or FinTech, has brought about significant changes in how transactions are conducted within these sectors. This shift towards FinTech is reshaping the way energy payments are processed and managed in the energy, oil, and gas industries. By challenging traditional payment methods, disrupting established norms, and fostering an environment of innovation and competition, FinTech is driving transformative changes in the operational structures of energy institutions.

3. Material and Methodology

Research Design: This study utilized a mixed-methods research design to thoroughly investigate the influence of FinTech on enhancing efficiency in energy payments. By integrating qualitative and quantitative data collection approaches, the research aimed to offer a comprehensive insight into how FinTech is reshaping the landscape of energy transactions. The qualitative phase involved expert interviews and thematic analysis, while the quantitative phase employed surveys and statistical analysis to provide a holistic perspective.

- **Surveys:** A structured survey questionnaire was distributed to a diverse sample of energy consumers, FinTech users, and financial industry professionals. The survey collected quantitative data on user preferences, satisfaction levels, and expectations regarding FinTech-driven energy payment services through standardized multiple-choice questions.
- **Expert Interviews:** In-depth interviews were conducted with key stakeholders in the FinTech and energy sectors, including FinTech entrepreneurs, energy executives, regulators, and technology experts. Semi-structured interviews were utilized to delve into their perspectives on the current and future impact of FinTech on energy payments.
- **Secondary Data Analysis:** A comprehensive analysis of existing literature, industry reports, and regulatory publications was carried out to gather secondary data. This analysis provided contextual insights into the historical evolution, current status, and potential future directions.
- **Focus Group Discussions:** Organized with representatives from FinTech firms, energy companies, and end-users. Open-ended questions used to facilitate a dynamic exchange of ideas.

3.1. Inclusion and Exclusion Criteria

- **Surveys:** Survey participants included energy consumers, FinTech users, and financial industry professionals from diverse demographic backgrounds to ensure a representative sample reflecting various user perspectives.
- **Participants:** In-depth interviews and focus group participants were selected based on their expertise in FinTech, energy, and regulatory domains. Participants included FinTech entrepreneurs, energy executives, technology experts, and regulators.
- **Secondary Data Analysis:** Relevant and recent sources from academic journals, industry reports, reputable publications were included, while outdated or non-credible sources excluded.

3.2. Ethical Considerations

- **Data Security:** Stringent measures were implemented to securely store collected data with restricted access to protect against unauthorized use or disclosure.
- **Informed Consent:** Before taking part in the study, all interviewees, focus group participants, and survey respondents received comprehensive details about the research goals, processes, and possible risks and benefits. Informed consent obtained to ensure voluntary participation.
- **Confidentiality:** Strict confidentiality measures upheld throughout the research. Data collected will be anonymized, and participants will be guaranteed that their identities will remain undisclosed in any research findings.
- **Researcher Neutrality:** Acknowledging personal biases, steps taken to mitigate their impact on the research. A neutral and unbiased approach was maintained to uphold the integrity of the study.

4. Results and discussion

Artificial Intelligence (AI) and Machine Learning (ML) have emerged as pivotal technologies across various industries, reshaping the way businesses operate and deliver services. In recent years, these advanced technologies have found widespread applications beyond the financial technology (FinTech) sector, impacting sectors such as healthcare, retail, manufacturing, and more. AI and ML, driven by sophisticated algorithms, have revolutionized processes and decision-making, leading to enhanced efficiency and innovation. One of the key areas where AI and ML have made a significant impact is in fraud detection. These technologies can analyze vast amounts of data to identify patterns and anomalies, enabling real-time detection of potential fraudulent activities. By leveraging AI and ML for fraud detection, businesses across different industries can enhance security measures, protect customers, and mitigate financial risks.

Another notable application of AI and ML is in customer service through the use of chatbots. These virtual assistants powered by AI can interact with customers in a natural language format, providing personalized support, answering queries, and facilitating transactions. Chatbots have revolutionized customer service by offering round-the-clock assistance, improving response times, and enhancing overall customer satisfaction levels. Moreover, AI and ML technologies have enabled businesses to streamline operations, reduce costs, and enhance risk management practices. By automating repetitive tasks, optimizing processes, and personalizing customer experiences, organizations can drive innovation and competitiveness in their respective industries. The transformative role of Artificial Intelligence and Machine Learning extends far beyond the FinTech sector, impacting various industries and revolutionizing the way businesses operate and deliver services. With their ability to enhance decision-making, automate tasks, and improve customer experiences, AI and ML technologies continue to drive innovation and efficiency across different sectors.

The impact of mobile apps on financial services has been transformative, revolutionizing the way people access and utilize financial tools. Mobile apps have democratized access to financial services, making them more inclusive and user-friendly for a wide range of consumers. Key innovations such as digital wallets, peer-to-peer payment apps, and mobile banking solutions have reshaped the financial landscape. Digital wallets streamline payment processes, peer-to-peer payment apps simplify money transfers, and mobile banking solutions empower users to manage their finances on-the-go. The accessibility and convenience offered by mobile apps have eliminated traditional constraints, allowing users to conduct financial transactions anytime, anywhere, and take control of their financial activities with ease.

Cloud computing has revolutionized the FinTech industry, providing startups with scalability, flexibility, and cost-efficiency that traditional on-premise solutions cannot match. By leveraging cloud technology, FinTech companies can rapidly deploy new services, scale operations, and drive innovation without heavy infrastructure investments, leading to faster growth and success in a competitive market. The agility, speed-to-market, and cost savings offered by cloud computing empower FinTech startups to focus on growth, innovation, and customer satisfaction, ultimately driving success in the industry. As cloud technology evolves, its impact on FinTech is expected to continue shaping the future of financial services and fostering innovation and growth.

In the realm of financial technology, cybersecurity has become a critical concern for FinTech companies due to the increasing volume of digital transactions and the sensitivity of financial data. Robust cybersecurity measures are essential to safeguard customer information, prevent cyber threats, and maintain trust in the digital financial ecosystem. Encryption is a key technology employed in cybersecurity within the FinTech industry, converting sensitive data into a coded format that can only be accessed by authorized parties with the corresponding decryption key. Biometrics, such as fingerprint scanning and facial recognition, enhance authentication and authorization processes, providing a secure and convenient way to verify user identities. FinTech companies also utilize advanced security technologies like multi-factor authentication, SSL protocols, and intrusion detection systems to fortify their cybersecurity defenses, detect unauthorized access, and prevent data breaches and cyber attacks. Continuous monitoring, threat intelligence, and incident response capabilities are crucial for FinTech companies to proactively identify and mitigate cybersecurity risks, ensuring the integrity and availability of financial services and transactions. By investing in robust cybersecurity measures and staying vigilant against emerging threats, FinTech companies can protect customer data and maintain trust in the digital financial landscape.

Exploring collaborative models, strategic partnerships, and potential challenges in the evolving financial ecosystem can offer valuable insights into the future of financial services. Understanding how traditional banks can embrace FinTech innovations while navigating disruptions is crucial for sustainable growth and competitiveness in the sector. Innovations in payment systems, such as contactless payments, decentralized finance (DeFi), and central bank digital currencies (CBDCs), are shaping the landscape of financial transactions. Assessing the implications of these advancements for financial intermediaries and monetary policy can provide insights into potential disruptions and opportunities in the payment ecosystem driven by FinTech.

The intersection of behavioral finance and FinTech offers insights into how digital platforms leverage consumer behavior to design personalized financial services and enhance decision-making processes. Leveraging behavioral insights can improve financial literacy, promote responsible financial behavior, and enhance customer experiences, shaping the future of banking services in the digital era. Investigating the potential of FinTech to facilitate cross-border financial transactions and investments is crucial for understanding the global impact of technological advancements in the financial sector. Addressing challenges related to regulatory harmonization, currency exchange, and global financial stability can illuminate opportunities and obstacles in enabling seamless cross-border financial services through FinTech solutions. Exploring the integration of FinTech in supporting sustainable and socially responsible banking practices is essential for promoting responsible financial services. Assessing the potential for FinTech to contribute to Environmental, Social, and Governance (ESG) goals, including climate finance, ethical investments, and social impact initiatives, can drive positive change in the industry and align financial services with broader societal and environmental objectives.

The convergence of AI, blockchain, and fintech represents a significant advancement in the field of ICT. Blockchain technology, originally developed to support Bitcoin algorithms, has expanded its applications beyond cryptocurrency, known for its data privacy, security, and decentralized nature. It has revolutionized data management and transactions across sectors like banking, healthcare, and others, offering decentralized solutions to enhance efficiency, security, and transparency in operations. On the other hand, AI has evolved significantly, especially with the introduction of deep learning (DL) methods, creating intelligent network systems that excel in handling complex, non-linear data. AI finds applications in various fields such as smart energy systems, healthcare, finance, gaming, and cybersecurity.

Blockchain technology has been widely adopted in information technology due to its numerous advantages. Initially developed to support Bitcoin algorithms, blockchain has been applied in various scientific areas, decentralizing currency transactions and digital payment systems. It is utilized across industries to improve workflows, enhance data privacy and security, increase efficiency, and reduce organizational costs. In the healthcare sector, blockchain's decentralization feature allows stakeholders to access patient records without involving third parties in global health records. AI has made remarkable progress, transitioning from limited success to rapid growth, particularly with the introduction of DL methods. These advanced algorithms have overcome limitations of traditional neural networks, especially in handling complex and non-linear data effectively. The scope of AI has expanded significantly, showcasing its potential in various industries.

The study gives impactable remarkable points to make a note of:

In the convergence era, features were categorized into data manipulation, regulations, applicability to legacy systems, compatibility and hardware issues. This study provides insights into the key features of the intersection of AI, blockchain, and Fintech, such as data security, encryption, sharing, efficiency, collective decision-making, decentralized intelligent systems, transparency, automated decision systems, and financial applications

Data manipulation is of critical importance for individuals and organizations. This work outlines four key features aimed at ensuring comprehensive data protection, accurate transfer, and secure storage within systems integrating AI, blockchain, and fintech. Privacy is a crucial concern in a blockchain environment where each participant has access to an identical copy of the shared database. This raises privacy-related considerations regarding data access, transactions, and smart contracts. AI can address privacy challenges

- **Data encryption:** Encrypted data offers significant advantages over plaintext, especially when integrated with AI and encryption algorithms in the domain of data security.
- Blockchain systems containing extensive personal information require stringent privacy measures.
- **Data security:** Blockchain technology provides exceptional security for data storage, creating a secure environment for sensitive and confidential information. This secure setup allows AI algorithms to operate on protected data, significantly improving decision-making accuracy. The application of blockchain in machine learning (ML) tasks enhances the quality of learning data and encourages data creators to share resources.

4.1. When AI and blockchain are combined, traditional systems operating based on these technologies are expected to be improved. This integration enhances various aspects of the system

Automated decision system: AI-generated decisions can pose challenges when users lack understanding or trust. Blockchain's distributed ledgers record transactions, enhancing auditing and decision transparency. Advanced machine learning algorithms improve AI's ability to handle complex situations, providing unbiased and tamper-resistant real-world considerations. This results in more consistent and trustworthy data-driven decision-making by AI. The integration of blockchain and AI allows for automatic transaction data handling, while AI-assisted online learning enhances blockchain algorithms. Collective decision making: Centralized systems typically require coordinated node processing for collective goals, often involving a third party. Blockchain eliminates this need, enabling nodes to autonomously make decisions. Voting techniques in blockchain enhance decentralized decision-making in AI, particularly in machine learning. AI activities such as model construction and training are recorded on the blockchain, creating a highly trustworthy and unalterable data-sharing system.

- **Decentralized intelligent systems:** Blockchain enhances decentralized systems and coordination platforms for AI, including methods, data, and computing power. The integration of AI and blockchain helps develop a new ecosystem of decentralized economies by utilizing blockchain to enhance the dependability, security, transparency, trustworthiness, and administration of data and algorithms within AI applications. Blockchain can fuel decentralized marketplaces and coordination platforms for multiple aspects of AI, enhancing the transparency, explainability, and trustworthiness of AI decisions. AI can simplify decisions related to blockchain parameters and trade-offs, automating and optimizing blockchain for improved performance and governance. Integrating blockchain technology with other distributed systems, such as robotic swarm systems, enhances security, autonomy, flexibility, and profitability of robotic swarm operations. This combination leverages the decentralized and cryptographic features of blockchain to secure data, improve decision-making autonomy within the swarm, increase operational flexibility, and potentially lead to more profitable outcomes. The decentralization of swarm intelligence algorithms, where computing systems operate with autonomous components connected by a network, aligns with blockchain technology principles. Blockchain's decentralized nature facilitates convenient sharing of AI training data, processes, and pre-trained models, highlighting a trend in leveraging decentralized architectures to enhance collaboration and trust within intelligent systems. AI algorithms protect data confidentiality and privacy on the blockchain, serving as an innovative filing system for digital information with encrypted, distributed ledger format to store data securely. Collaboration and data sharing among healthcare organizations enhance interoperability, health outcomes, and streamline the system.
- **System security:** Transparency system: Data collection in machine learning relies on trustworthy user interfaces. Blockchain ensures the execution of source code on local nodes without third-party servers, managing user contributions and activities for transparency. AI decision systems require traceability, auditability, and explainability for transparency. Recording AI decision processes on blockchain enhances

transparency and user trust. Audit trails and decision-making processes in blockchain enhance traceability. However, further research is needed to improve the auditability of blockchain, particularly focusing on data storage and transactions for enhanced transparency. Blockchain security focuses on vulnerabilities at the application layer and encryption methods. Machine learning-driven intrusion detection and prevention systems can address application layer vulnerabilities. Swarm intelligence, a computational intelligence technique, can enhance intrusion detection effectiveness, while computational intelligence models can improve encryption robustness, strengthening blockchain resilience. Machine learning in blockchain is used to detect attacks and either protect systems or prevent attacks from spreading.

- **The convergence** of blockchain and AI has ushered in a new era of technological innovation, with the combination of these disruptive technologies poised to have a significant impact across various sectors. From finance and healthcare to communication and network security, the integration of blockchain and AI is transformative. A few key areas have been identified that benefit significantly from this integration, including IoT applications, energy, smart cities, finance, and big data manipulation, etc.,

The Internet of Things (IoT) has revolutionized data connectivity and exchange between physical and virtual entities, but traditional centralized IoT systems face challenges like single points of failure and data security concerns. Transitioning to an intelligent distributed ledger system, combining blockchain, AI, and IoT technologies, offers numerous benefits and opportunities for innovation. In the energy sector, technology is enabling direct energy transactions between consumers and suppliers, reducing costs and improving transaction monitoring efficiency. Technology applications in energy systems enhance tasks like predicting energy demand, assessing business partners, and transforming traditional grids into automated, reliable, sustainable, and secure services. Studies have explored integrating technology in distributed environments, power electronics, electric vehicles, and cybersecurity to optimize energy generation, consumption, and transfer processes. Models utilizing algorithms and technology aim to enhance transaction security, real-time pricing accuracy, and overall efficiency in the energy sector.

The concept of a smart city in the modern information age involves leveraging advanced technologies to enhance efficiency and sustainability. Blockchain technology plays a crucial role in transitioning traditional systems into digitally intelligent urban environments, finding applications in diverse sectors like supply chains, finance, the Internet of Things (IoT), and cybersecurity. The combination of blockchain and AI significantly enhances smart city networks, making them more effective and sustainable. A blockchain-based infrastructure has been introduced to strengthen security and privacy in smart contract services for IoT devices in smart cities. This framework, which combines AI and blockchain, ensures secure data transfer for IoT devices using cyber-physical sharing economy services, defining a new generation of smart city systems. It facilitates complex service provision on a global blockchain level without needing a certificate authority for user authentication. Moreover, blockchain has been implemented as a decentralized technology in intelligent traffic models, allowing vehicle-to-vehicle information sharing without a central authority. This peer-to-peer approach ensures direct node connectivity for right-of-way acquisition, with lane property rights and consensus achieved through smart contracts.

Instead of focusing on applying blockchain and AI to improve traditional technology systems, researchers have investigated the application of blockchain and AI to solve environmental pollution. The rapid growth of the world population directly contributes to environmental damage, especially waste pollution. To address this challenge, machine learning techniques and blockchain technology have been combined to classify waste objects or products, providing recommendations to users on how to reuse or recycle these waste objects or products. The developed approach is made easily accessible to end-users through a website.

The integration of AI and blockchain is reshaping numerous sectors, offering innovative solutions and posing new challenges. In healthcare, the predictive analytics of AI, combined with the secure data management of blockchain, is revolutionizing patient care and record keeping. The finance sector is witnessing the emergence of smart contracts, while cybersecurity benefits from enhanced security controls. This transformative impact signifies a shift in how technology addresses complex problems, but it also brings forth new questions and considerations, particularly in terms of scalability, interoperability, and governance.

AI-powered blockchain solutions offer unprecedented transparency, security, and efficiency, revolutionizing sectors such as supply chain management, finance, and healthcare. These technologies enable automated decision making, smart contracts, and Decentralized Autonomous Organizations (DAOs), paving the way for new business models and collaborations. Governments are also exploring the integration of AI and blockchain to bolster data security, streamline administrative processes, and foster digital identity initiatives. Moreover, it has been emphasized that the transformative impact of AI and blockchain on the future of work could lead to the creation of millions of new jobs. This

synergy between AI and blockchain technologies signifies a profound shift towards decentralized, AI-driven economies, promising immense opportunities for innovation and growth.

AI applications combined with blockchain, including decentralized marketplaces, data exchange platforms, and autonomous agents, demonstrate blockchain's capacity to support diverse AI applications. The variation in consensus algorithms and governance models reflects continuous innovation aimed at optimizing processes. The assortment of blockchain types and layers used by these projects signifies the evolving complexity of blockchain ecosystems and the development of platforms for specific applications. In summary, the current innovations at the AI-blockchain nexus indicate a dynamic and rapidly advancing field.

4.2. In the field of Energy Trading particularly Oil, Gas, Electricity, Natural sources etc., the impact is like this

A decentralized smart grid relies on Distributed Energy Resources (DERs) like solar panels and windmills to generate power locally, addressing energy loss and fault tolerance issues. However, a reliable platform for energy trading is needed to facilitate the sale of excess energy by DERs. Blockchain technology, with its fault-tolerant nature and support for smart contracts, offers a solution for efficient energy trading. By automating buy/sell energy contracts on a blockchain-based system, transaction costs and settlement times can be significantly reduced. A decentralized smart grid using blockchain technology can respond dynamically to supply and demand, enabling near-real-time transactions and payments. This can lead to lower green energy costs, increased efficiency, and improved monitoring of energy consumption and generation.

In a Peer-to-Peer (P2P) energy trading system facilitated by blockchain, surplus electricity can be exchanged directly between parties on a connected grid. Blockchain provides a secure platform for tracking asset transactions, such as energy units, in a transparent and decentralized manner. Smart contracts automate energy buying and selling based on supply and demand, making blockchain an attractive solution for distributed energy companies. Consumers in a P2P trading system can choose their power source, view real-time prices, and potentially reduce costs by eliminating intermediaries.

Solar energy, a common DER, can be traded in a P2P system, allowing consumers to purchase surplus renewable energy from their neighbors. Blockchain technology enables efficient and transparent trading of renewable energy, empowering consumers to make informed choices and potentially reduce costs by bypassing traditional energy brokers.

Localized microgrids offer a more efficient and dynamic alternative to centralized power generation systems, reducing power loss along transmission lines and responding effectively to local energy needs. Distributed Energy Resources (DERs) within microgrids, such as solar and wind power, can lower costs, minimize waste, and promote environmental sustainability. Blockchain trading addresses the intermittency of renewables by facilitating the sale of surplus power and enabling easy access to alternative energy sources when needed.

In addition to its applications in renewable energy, blockchain technology has significant potential in the oil and gas industry, improving data transparency, transaction efficiency, and security across different segments of the industry. As the energy market evolves globally, countries like Australia, Estonia, Spain, Malaysia, the United States, and South Africa are exploring innovative energy transaction solutions, including blockchain-based Peer-to-Peer (P2P) trading. Research on blockchain's impact on energy trading is expanding, with successful examples like the creation of a microgrid in Brooklyn showcasing the potential for communal energy networks managed by traditional utilities but operated by community members.

Blockchain technology offers a decentralized data platform for the energy sector, revolutionizing electricity trading by eliminating intermediaries, streamlining transactions, and enhancing transparency and security. While blockchain has diverse applications beyond finance, its potential in energy trading lies in addressing inefficiencies, reducing costs, and improving data management. Despite its benefits, blockchain implementation may face challenges such as slow adoption, security concerns, regulatory hurdles, and disruptions to existing business models in the energy industry. By leveraging blockchain's **transparency, security, and efficiency**, electricity trading can be transformed through streamlined processes, reduced errors, lower credit risks, and improved data access for all parties involved. Blockchain platforms enable real-time data sharing, automated transactions, and enhanced risk management, ultimately allowing companies to process more data securely and **efficiently**.

Blockchain plays a crucial role in the energy sector by enabling decentralized power grids, transactive energy frameworks, and peer-to-peer (P2P) energy trading. Distributed Energy Resources (DERs) like solar panels and wind

turbines are essential components of a decentralized grid, allowing owners to sell surplus electricity through net metering. However, regulatory barriers often hinder P2P trading, necessitating new regulations to promote deregulation while safeguarding consumers' interests.

Blockchain technology offers transparency, security, and efficiency in energy transactions, enhancing consumer control over energy sources and costs.

4.3. Challenges

The convergence of Artificial Intelligence (AI), blockchain technology, and Financial Technology (FinTech) in energy trading offers benefits such as increased efficiency, transparency, and automation. However, challenges like data security, regulatory compliance, interoperability, scalability, skill gap, and cost need to be addressed for the full realization of this convergence. Ensuring the security and privacy of data, meeting regulatory requirements, enabling seamless communication between technologies, handling large volumes of data, bridging the skill gap, and managing costs are key areas that require attention to harness the potential of AI, blockchain, and FinTech in energy trading effectively. Addressing these challenges will be essential for driving efficiency, transparency, and automation in the energy trading industry. The integration of technologies such as Intel SGX to enhance Trusted Execution Environments (TEEs) and the exploration of combining TEEs with blockchains for confidentiality in smart contracts are key developments in the blockchain-AI landscape. Ensuring secure storage and processing of sensitive data within enclaves created by TEEs, like Intel SGX, is crucial for maintaining the integrity of smart contracts and preventing cyberattacks. Improving blockchain engineering practices, coding languages, and tools for vulnerability assessment in smart contracts are essential to address security concerns and prevent losses. Decentralized oracles in smart contracts, while providing external functions for execution, may introduce centralization risks, which technologies like Chain link aim to mitigate. Fog computing extends cloud capabilities to edge networks, enhancing system speed in applications like autonomous vehicles, while blockchain secures AI-processed data. Research efforts are focusing on leveraging AI algorithms and fog computing to detect and prevent DDoS attacks in blockchain-IoT systems.

5. Conclusion

In conclusion, the convergence of Artificial Intelligence (AI), blockchain technology, and Financial Technology (Fintech) in energy trading represents a transformative shift towards increased efficiency, transparency, and automation in the global energy sector. This study has highlighted the key features and benefits of integrating AI, blockchain, and Fintech, including enhanced data security, encryption, collective decision-making, transparency, and automated decision systems. By analyzing the evolution of this technological convergence across different eras and applications, it becomes evident that the integration of these technologies is reshaping energy trading practices in areas such as cybersecurity, finance, Internet of Things applications, and smart cities.

The combination of AI for predictive analytics and automation, blockchain for secure and transparent transactions, and FinTech for seamless financial transactions and risk management is revolutionizing energy trading across various sectors including electricity, gas, oil, and non-renewable energies. This convergence is driving efficiency, reducing operational complexities, and improving overall performance in energy trading processes. As the energy sector continues to evolve, embracing the synergies of AI, blockchain, and Fintech will be crucial in navigating the challenges and opportunities presented by the changing landscape, ultimately leading to a more resilient, transparent, and automated energy trading ecosystem.

Finally, the convergence of Artificial Intelligence (AI), blockchain technology, and Financial Technology (Fintech) in energy trading represents a transformative shift towards increased efficiency, transparency, and automation in the global energy sector and also in the energy sector which represents oil, gas, electricity, and non-renewable sources.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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