

Geopolitical Conflicts: Blockchain Use in International Energy Trading

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ABSTRACT

This research explores how blockchain technology impacts energy markets, particularly during times of conflict and regulatory change. Geopolitical tensions often disrupt energy markets by affecting supply chains, prices, and access to resources. Energy trading becomes a strategic tool for securing reliable energy sources and managing risks. Technological advancements, evolving policies, and sustainability goals are reshaping the global energy landscape. Blockchain's decentralized and tamper-proof infrastructure offers solutions by maintaining immutable records of transactions, reducing fraud, and enhancing accountability. Case studies highlight how blockchain applications, including smart contracts and tokenization, improve efficiency and transparency in energy trade. However, regulatory challenges persist, particularly with privacy laws like GDPR. Adapting international agreements, such as the Energy Charter Treaty (ECT), to accommodate decentralized markets is crucial. Striking a balance between transparency, data protection, and regulatory compliance is necessary to enable blockchain's full potential in global energy trading.

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1. INTRODUCTION

The need for sustainability and the effective use of natural resources have become major global issues in the twenty-first century. Acknowledging the seriousness of these issues, the United Nations revealed a comprehensive framework in 2015 that included 17 Sustainable Development Goals (SDGs). With a focus on a wide range of issues from clean energy and climate action to poverty and hunger, these goals were created to

inspire global efforts towards a more sustainable future. Multidisciplinary cooperation plays an increasingly vital role as the globe struggles with the energy transition's complications. Engineers play a key role in creating and improving technologies that increase the efficiency of power generation. Economists examine market forces and legislative structures in the long-run to guarantee that the energy industry processes within a sustainable economic framework. International trade has faced a lot of changes

during the last century. Globalization has been continuing for several centuries with its peak during the Industrial Revolution. Removal of protectionism in world industrial markets, which started with the General Agreement on Tariffs and Trade (GATT), and was followed by the introduction of new policies, regulations, and institutions such as the World Trade Organization (WTO) is a crucial condition for the multilateral trading system. The multilateral trading system—under frameworks like the World Trade Organization (WTO)—has significantly expanded the scope of global production and distribution by reducing trade barriers, enhancing legal predictability, and promoting transparency. This environment has enabled the rise of complex global value chains (GVCs), where components of a single product are sourced, assembled, and sold across multiple countries [1-3]. As a result, multinational corporations have leveraged these networks to optimize costs, increase resilience, and access new markets, particularly in the energy and digital sectors. This system has made it easier for businesses to operate internationally and has helped to create a global marketplace. Trade barriers have been lowered, regulations have been standardized, and businesses have been able to grow, enter new markets, and create complex international supply chains. The complex energy industry is not distinguished from other trade markets by GATT, which is a fundamental component of WTO policies. This reflects the historical setting in which the GATT was established when the trade dynamics in the energy sector were not as significant or political as they are now. As a result, without taking into account the particular characteristics of energy markets. All energy trading, including goods and services related to energy, is protected by basic WTO regulations. The principles of Most-Favored-Nation (MFN) and National Treatment ensure that all WTO members do not discriminate between their trading partners and do not favor domestic products over imported goods.

More energy-producing nations have joined the WTO, allowing for greater energy trade and less monopolistic and state-owned enterprise influence [4]. Considering monopolies in the energy sector, there haven't been many in-depth multilateral GATT or WTO negotiations about the energy market. In the example of the natural gas

market, the significance of trade belongs to the model under which gas is traded. In the market-driven model, prices are regulated by supply-demand dynamics while in the state-driven model intervened by the government. The Energy Charter Treaty (ECT) is an example of a multilateral agreement signed in 1994 with the purpose of enhancing the energy market. ECT, the only multilateral agreement that specifically distinguishes and governs energy trading, was signed outside of the GATT/WTO framework [5]. Providing a narrow approach to energy cooperation and legal issues specific to the energy sector, ECT is a first-of-its-kind energy-related treaty that covers foreign investments, commercial relations, and non-discrimination and describes state-to-state and investor-to-state trade inside the energy market [6].

There are international organizations like the Organisation for Economic Co-operation and Development (OECD) and the International Energy Agency (IEA) that shape the view on both practical energy economy and theoretical energy economics. IEA specifies, qualifies, and assists in the integration of energy production, distribution, and long-term policies. For the energy market international agreements promoting cross-border energy cooperation are crucial to support investment, and interest and increase the number of participants. Energy trade makes energy affordable and available both domestically and globally. It should be mentioned that energy trade patterns have a major impact on the development of renewable energy. An increased number of trade relationships, increased trade intensity, and more significant trading partners within the traditional energy trade network are all beneficial to the development of a nation's renewable energy sector [7].

Over the past twenty-five years, the landscape of what is commonly known as traditional energy trading has been developing. As outlined in the introduction, this evolution has been influenced by agreements, policies, and organizational structures, ranging from the expansive frameworks of the WTO and GATT to the focused directives of the ECT. However, the traditional energy market is criticized for its lack of transparency, vulnerability to fraud, and centralized control by monopolies. Recently, more complex forms of competition and threats

have appeared, raising questions about the future network development and safety of global energy trading. Technological advancement can reshape energy trade and establish a new infrastructure. Dealing with transparency, fraud, and centralized control, the integration of cryptographic ledger systems, such as blockchain, offers a promising solution for addressing these challenges. The following parts of this article will examine the effects of geopolitical conflicts on energy trading and discuss how blockchain could offer a breakthrough approach to innovation of existing trading practices.

This study adopts a qualitative research approach grounded in a systematic literature review (SLR) to analyze the impact of geopolitical conflicts on the energy market and assess the role of blockchain in risk management. Academic articles, policy reports, and legal frameworks were reviewed to synthesize interdisciplinary perspectives from energy economics, international trade law, and digital technologies. This method enables a structured exploration of risk categories—such as price volatility, supply disruption, and regulatory uncertainty—and evaluates how blockchain features like decentralization, smart contracts, and transparency can mitigate these risks in energy systems.

2. ENERGY TRADING AND GEOPOLITICAL CONFLICTS

International energy markets play a crucial role, connecting nations through existing trade channels and influencing economic growth and environmental impact. Moreover, different countries respond differently to occurring conflicts changing their energy demand and energy related national goals. From an outlook of the global market, leaders in the export of natural gas are Russia, the United States, and Qatar. In recent years, the world has been shaken by the events of the geopolitical conflict in Eastern Europe. According to the European Commission's REPowerEU communication (2022), 90% of the EU's gas is imported, with more than 40% coming from Russia. Additionally, 46% of the EU's coal imports and 27% of oil imports were sourced from Russia in 2021 [8]. Existing energy trade channels were shut down, fuel prices rapidly increased, and the energy market went into crisis. Reliable on energy imports, countries were

forced to look for new energy sources. During geopolitical tension in Eastern Europe, China took its place as a main importer of Russian fossil fuels and changed market distribution. European countries at the same time found new energy suppliers and straightforwardly moved to renewable energy development. Such events have long-term implications, affecting not just immediate supply and prices, but also the strategic direction of energy policy and infrastructure development. The political characteristics exist in the fossil fuel and carbon trading markets [9]. The government can more precisely and timely modify the supply and demand policy for fossil fuels to avoid more extreme volatility. The International Monetary Fund (IMF) has noted that fluctuations in trade and geopolitical disputes are having an impact on the energy transition. The United Nations Development Programme (UNDP), for example, explains in its Arab Future Energy Index 2023 report [10] how geopolitical events and fluctuations in global oil prices have stimulated Arab nations to implement a range of reforms, such as cutting back on power generation subsidies and raising the proportion of renewable energy in their power generation. A review of recent literature, mentioned below, indicates that while geopolitical tensions—such as war, sanctions, and energy diplomacy—do play a major role in influencing energy trade, they are not the sole drivers of volatility. Technological advancements, especially in areas such as renewable energy generation, battery storage, smart grid development, and blockchain-based energy trading platforms, are reshaping global energy markets. For instance, Sovacool [11] highlights how innovation in renewables disrupts fossil fuel dependency; IEA [12] underscores the growing competitiveness of solar and wind; and Andoni et al. [13] explore how blockchain is transforming energy transactions. These studies collectively show that technological progress is a parallel force influencing pricing, supply chains, and trading models in the energy sector. This allows us to assume that with the correct adaptation of blockchain technology to the energy market, many problems that arose during conflicts will fade into the background, helping to stabilize the market environment. To suggest the use of blockchain in crises, we are also given the following research that the circulation of cryptocurrency during geopolitical conflicts has

increased significantly. Different groups use crypto to bypass sanctions, save money, and make secure payments [14, 15].

The digital landscape is changing in tandem with the energy sector. Blockchain has transformed currency and trade since its launch in 2008. The use of blockchain technology is becoming more widespread, and demand for it is rising. IDC, stated that global spending on blockchain solutions was \$6.6 billion in 2021 and is expected to reach \$19 billion by 2024 [16]. By 2025, the blockchain market is expected to grow to \$39.7 billion, according to Statista [17]. Between 2023 and 2030, the blockchain energy market is expected to grow at a compound annual growth rate (CAGR) of more than 71.1%, continuing its stellar trajectory [18]. In terms of the adoption and use of cryptocurrencies during the geopolitical conflicts, it seems that Ukraine rose to the third spot in the Chainalysis Global Crypto Adoption Index in 2022, while Russia was ranked ninth in the same year. Ukraine has received 212.2 million \$ donations in cryptocurrency according to the Elliptic Report 2023. Russia used Tether (USDT) in an attempt to evade sanctions and do international transactions [19]. The geopolitical risk index, cryptocurrency carbon emissions, renewable energy markets, and green financial assets were all studied. Global market forecast error variance is attributed to shocks, climate, and geopolitical risks to the tune of nearly 23 percent. One can attribute the remaining 77% to specific market factors [20]. Pairwise connectedness showed that the fuel and energy markets both influence and react to related shocks from other markets. In general, the energy consumption of cryptocurrencies and geopolitical risks are reliable indicators of market volatility. It's crucial to remember that gathering and analyzing data in conflict areas can be difficult. The impact of geopolitical risks (GPR) on energy imports and exports in developing economies is extensive. As an example their results showed that geopolitical risk had a significantly negative impact on imports in emerging economies, which is in line with the findings of the benchmark regression, natural gas increased prices had a total negative effect of -0.306 on energy exports in emerging economies, and 16.01% in summary [21]. Nevertheless, the effects of a geopolitical conflict take time to appear, it is difficult to draw firm conclusions. It can be assumed that due to the features of the

blockchain, its demand during geo-political conflicts for energy trade will only grow, establishing new trading channels, just as the general demand for blockchain increased during the conflict between Ukraine and Russia.

In addition to the disruptions caused by the conflict in Eastern Europe, other regions around the world have experienced similar challenges in maintaining stable energy trade due to geopolitical tensions according to the IEA report [22]. The Middle East, a major oil-producing region, has seen conflicts in Iraq, Syria, and Yemen that have historically driven volatility in global oil prices. Meanwhile, territorial disputes in the South China Sea pose risks to LNG shipments vital to Asia-Pacific economies, and unrest in Nigeria's Niger Delta has periodically impacted oil production, causing supply chain disruptions in Africa. These examples demonstrate that geopolitical tensions, regardless of location, continue to reshape the dynamics of international energy markets, necessitating innovative strategies to enhance resilience.

3. ENERGY TRADING AND GEOPOLITICAL CONFLICTS

Blockchain technology has gained rapid popularity in the last decade. People use cryptocurrency trading to earn income, save money, make secure transfers, and circumvent sanctions. Initial research into blockchain technology was conducted in the 1990s. A secure chain of blocks was first proposed in 1991 by Stuart Haber and W. Scott Stornetta. Setting up a system that would stop people from interfering with document timestamps was their aim [23]. Officially stated that Satoshi Nakamoto founded the distributed ledger system nowadays known as blockchain in 2008 [24]; it is the foundational technology behind cryptocurrencies, Non-Fungible Tokens (NFTs), and smart contracts. Within the "chain" where all data is connected to both the previous and the next, technology itself presents "blocks." A blockchain starts with a genesis block that has no prior hash. All subsequent blocks in the chain have hashes that contain distinct cryptographic information about both the prior and subsequent hashes; these hashes are all connected and correlated. No entity within the system can alter or compromise data; in order to make changes to a single block of data,

the entire chain must be reminded. Blockchain, then, offers permanence, transparency, and security; for instance, Widely used Bitcoin has never experienced a hack. NFTs' unique ownership identifier is recorded on the blockchain. The uniqueness of NFTs does not allow it to be duplicated, it can only be sold to other authorities. However, it should be mentioned that maintaining the NFTs market costs a lot of energy, which opens questions to the reasonability of its usage in terms of sustainability. Ethereum, another blockchain-based platform, has expanded the technology's utility by facilitating smart contracts. These are automated agreements that self-execute under specific conditions, mirroring traditional contracts without the need for intermediaries. After the first run smart contract cannot be moderated, so the correctness of the code plays a key role in future executions. Blockchain networks maintain consensus through various mechanisms, ensuring all participants agree on the state of the ledger. Proof of Work (PoW), utilized by Bitcoin, demands the solving of complex cryptographic puzzles to securely add new blocks, though this process is notoriously energy-intensive. Ethereum, on the other hand, has adopted Proof of Stake (PoS), a more energy-efficient alternative where participants validate transactions based on their stake in the network. Validating its tokens is a prerequisite for PoS members to join a consensus. It appears to operate remotely like a lottery in which you must purchase an invitation to start a new block [25].

Smart contracts to enable complex usage and become smart, need data outside of blockchain. In blockchain programming such concepts as Oracle are used. Oracles like bridges allow data flow from public or private sources inside the closed structure. Smart contracts are actively used for carbon trading under the Kyoto Protocol, especially in China and South Korea. They are also used for supply chain tracking. And for the upcoming new rapidly developing hydrogen market in Europe. The decentralized P2P market involves concerns about data privacy, security, and energy trading efficiency. Any smart contract should necessarily consist of registration, trading, and verification parts. To be able to interact with a framework environment. The energy trading process can be made more efficient by using blockchain technology. Blockchain technology can guarantee the tamper-

proof, secure, and decentralized nature of all related information. Furthermore, the mechanism allows tracking data related to, for example, carbon offsets, such as carbon credits or renewable energy certificates, which would improve process reliability and ease of verification [26].

Protecting privacy and controlling input data is highly important to organize flow of quality information and output. During geopolitical conflicts data privacy plays a key role in source protection, so it is important to understand regulations with which blockchain will deal in established energy markets besides WTO regulations. Blockchain technology's decentralized and immutable nature creates some conflicting issues regarding privacy regulation. These difficulties are best demonstrated by the enforcement of privacy laws such as the General Data Protection Regulation (GDPR), which has strict privacy requirements that may conflict with some of blockchain's features. For the notice blockchain uses data outside of mechanism structure, through blockchain oracles data flow could be allowed. Under General Data Protection Regulation People has right to have their data erased or corrected – GDPR's "right to erasure" and "right to rectification". Thus data should be protected from misuse. But blockchain nature cannot allow data to be easily changed or deleted. The organizational complexity of GDPR, especially with regard to data control and interoperability, arises from the integration of blockchain's decentralized architecture. The legal context of blockchain presents a challenge to data auditability and compliance because its immutability violates GDPR's right to erasure, and its transparency raises privacy concerns [27]. Thus further blockchain's implementation under GDPR could be challenging.

3.1 Smart Contracts for energy trading: case studies

To demonstrate the widespread use of smart contracts, a study of the literature and existing projects was conducted. Zhou et al. [28] stated that blockchain technologies have great potential for distributed energy trading because of their traceability and verification. They also offer safe transactions, cheap compliance costs, and quick data transfer processing. Their study presents

the structural configurations and the mechanism of blockchain technologies. In P2P energy trading, the importance of energy security and data privacy is emphasized. Finally, it is shown that blockchain applications can use automated smart contracts to create a safe and unhackable energy trading environment. There are also details about blockchain's potential for multi-energy trading platforms.

Wang et al. [28] introduced a promising blockchain-enabled approach to improve energy system flexibility, enhance peer privacy, and ensure transaction traceability in real-time peer-to-peer (P2P) energy trading markets. Their research highlighted the challenges of implementing blockchain solutions compatible with energy trading, emphasizing the importance of aligning business model viability, blockchain configuration, and physical constraints. The study utilized a permissioned Hyperledger Fabric (HF) blockchain to test practical applications within smart community energy systems. This decentralized model aimed to facilitate near-real-time bilateral energy trading by enabling direct negotiations between producers and consumers, without the need for intermediaries. By dynamically balancing supply and demand within the network, the system demonstrated the ability to enhance market stability and transaction efficiency—critical during periods of geopolitical instability, where centralized energy markets may face disruptions. Furthermore, the research stressed the need for robust privacy and data security mechanisms to maintain trust among participants in a decentralized system. The outcomes confirmed that the HF-assisted platform was scalable and effective, validating its potential to support resilient and decentralized energy trading markets. These findings align with the growing demand for secure and adaptable energy trading platforms that can operate efficiently under conflict conditions, offering a pathway toward more transparent, reliable, and flexible global energy markets.

Buccafurri et al., [29] suggested an Ethereum-based energy trading alternative. The goal of the blockchain alternative is to provide a workable plan that meets the requirements of energy trading in smart grids, with the crucial component being the non-disclosure of network peers' identities beforehand. The real smart contract structure was described, the

highest scalability was given to public blockchain and the lowest to private. A review of the smart contract code for energy was introduced by Kirli et al. [30]. Their research stated that peer-to-peer energy trading, automated demand-side response, distributed control among network operators, and smart electric vehicle charging are among the applications of smart contracts. There are many options available, ranging from distributed control over energy assets to automation of market and billing processes like market clearing and settlement operations. For example, blockchain-based decentralized autonomous organizations (DAOs), which utilize smart contracts for automatic agreements among their members, may raise perspectives for the future of the energy market. Damisa et al. [31] concluded in the research that Ethereum smart contracts are suitable for P2P energy trading, Solidity written smart contracts enable energy auctions and SR trading and validate effectiveness in facilitating energy payment transactions.

Zhang et al. [32] also demonstrated that blockchain technology can significantly enhance carbon credit trading by improving transparency and traceability through real-time verification, reducing fraud, and lowering transaction costs by eliminating intermediaries. Smart contracts automated key processes like credit issuance and compliance checks, speeding up transactions and increasing efficiency. The platform also enabled greater participation by smaller producers, enhancing market liquidity—an important advantage during geopolitical disruptions. However, challenges related to privacy compliance (e.g., GDPR) and scalability were noted, with permissioned blockchains suggested as a solution. The study emphasized that regulatory harmonization is crucial for broader adoption and cross-border trading. These findings highlight blockchain's potential to create a more resilient and efficient energy trading system under conflict conditions.

Marszal et al. [33] explored the application of blockchain technology to improve energy access in developing regions, focusing on a project implemented in rural Africa. This initiative utilized blockchain-based peer-to-peer (P2P) energy trading, supported by smart contracts and microgrids powered by solar energy. The

system allowed local communities to trade energy credits directly without reliance on external utilities or centralized infrastructure, addressing the challenge of limited energy access in remote areas. By decentralizing energy management and enabling transparent, tamper-proof transactions, blockchain enhanced both the efficiency and reliability of energy distribution. The study highlighted that smart contracts automated key trading processes, reducing administrative costs and improving transaction speed, which proved particularly beneficial in regions with minimal technological infrastructure. Additionally, the decentralized nature of the system promoted greater energy independence and economic empowerment for local communities. The findings suggest that blockchain-based energy trading systems have the potential to expand access to sustainable energy in developing economies, providing a resilient solution to energy scarcity and infrastructure challenges—particularly under conditions of political or economic instability. This research aligns with global efforts to use innovative technologies to enhance energy security and sustainability, especially in regions prone to disruptions in traditional energy supply chains.

4. FUTURE OUTLOOK

The future of blockchain technology in energy trading lies at the intersection of innovation, sustainability, and global geopolitics. As energy markets become increasingly interdependent, the role of international trade in ensuring the stability of energy supplies has grown more complex. Geopolitical conflicts, such as those in Eastern Europe and the Middle East, have highlighted the fragility of traditional energy trade networks, where disruptions ripple through global economies. Against this backdrop, blockchain offers a potential solution to mitigate trade disruptions and enhance resilience, but its adoption must navigate numerous challenges. One of the key advantages of blockchain in international energy trade is its capacity to decentralize and secure transactions. By creating a transparent and tamper-proof ledger, blockchain reduces the risk of fraud, simplifies cross-border energy trade, and establishes trust between trading partners, even during periods of conflict. In instances where traditional supply chains are

disrupted—such as the redirection of Russian fossil fuel exports during the conflict in Ukraine—blockchain could enable alternative trading routes and platforms that bypass political bottlenecks. For example, tokenized energy assets and smart contracts could facilitate direct energy exchanges between producers and consumers without requiring intermediaries.

However, the decentralized nature of blockchain also introduces challenges for international governance and trade. Current multilateral frameworks, such as those established by the World Trade Organization (WTO) and the Energy Charter Treaty (ECT), were designed for traditional trade models and struggle to accommodate blockchain-based systems. These frameworks do not yet fully address the nuances of decentralized trading, such as the legal status of smart contracts or the regulation of tokenized energy markets. For instance, ensuring compliance with most-favored-nation principles and non-discrimination rules in blockchain-enabled energy trading may require significant adaptations to existing agreements. Geopolitical conflicts further complicate the adoption of blockchain. While the technology has shown promise in maintaining energy trade during crises, it can also be exploited for unintended purposes. For example, during the Russia-Ukraine conflict, cryptocurrencies were used both as a means of international aid and to circumvent sanctions. A similar dynamic could emerge in energy trading, where blockchain-based systems enable transactions that bypass global sanctions or regulatory oversight. This dual-edged nature underscores the need for stronger governance and international collaboration to prevent misuse while fostering innovation. Additionally, disruptions in international trade caused by conflicts often lead to shifts in energy demand and supply. As countries adapt to new energy realities—such as Europe's pivot away from Russian energy supplies—the integration of renewable energy sources and decentralized systems becomes critical. Blockchain could play a transformative role here by streamlining the certification and trade of renewable energy credits, enabling cross-border electricity exchanges, and facilitating decentralized energy production in conflict-affected areas. These capabilities align

with the broader global shift toward sustainability and energy security. Despite its promise, blockchain's potential in energy trade is limited by technical and regulatory challenges. Cross-border transactions rely on harmonized standards, yet there is currently no global consensus on blockchain governance. Furthermore, integrating blockchain into existing infrastructure requires significant investment and technical expertise, which may be difficult to secure in developing or conflict-affected regions. Privacy regulations, such as GDPR, add another layer of complexity, particularly given blockchain's immutable nature.

Looking ahead, blockchain's success in international energy trade will depend on the ability of nations and organizations to address these barriers. International cooperation will be essential to establish standardized protocols, resolve regulatory conflicts, and create mechanisms for monitoring and controlling blockchain-enabled energy markets. While smart contracts enable automation and transparency in energy transactions—especially in decentralized or peer-to-peer contexts—traditional trading mechanisms such as centralized exchanges, long-term bilateral contracts, and regulated market operators continue to dominate large-scale energy markets. The effectiveness and adoption of smart contracts are highly dependent on regulatory frameworks, market maturity, and technological readiness. Thus, both models currently coexist, serving different segments of the market. A more detailed comparison between these mechanisms represents a relevant avenue for further empirical research.

Pilot projects and regional initiatives can serve as testbeds for new models of energy trade, providing valuable lessons for scaling up the technology on a global level. In a world where energy trade is increasingly shaped by geopolitical dynamics, blockchain offers a unique opportunity to create resilient and adaptable systems. However, its adoption will require navigating the delicate balance between innovation and regulation, decentralization and control, and sustainability and practicality. With the right strategies and partnerships, blockchain could become a cornerstone of a more secure, even in the face of ongoing disruptions and uncertainty.

5. CONCLUSION

This research highlights the role of blockchain technology in energy trading, particularly in addressing disruptions caused by global geopolitical tensions. Conflicts in regions such as Eastern Europe, the Middle East, and Africa continue to destabilize traditional energy supply chains, causing price volatility and insecurity. Blockchain's decentralized, secure, and transparent infrastructure offers a solution by enabling tamper-proof record-keeping, peer-to-peer (P2P) trading, and automation through smart contracts, sustaining trade even under conflict conditions.

This study demonstrates that blockchain applications, including smart contracts and tokenized assets, enhance the scalability and reliability of energy markets. Case studies show its successful use in carbon credit trading and renewable energy systems. However, regulatory challenges persist, particularly with privacy laws like GDPR, as blockchain's immutability conflicts with data protection requirements. Technical and legal barriers to cross-border implementation further complicate adoption.

Additionally, the use of blockchain and cryptocurrencies during conflicts raises governance concerns. Countries like Ukraine and Russia have illustrated both the benefits and risks of blockchain in bypassing traditional trade restrictions and sanctions. This underscores the importance of developing regulatory frameworks that balance innovation with oversight.

Blockchain can also accelerate the shift to renewable energy by streamlining the verification and trade of renewable energy credits and carbon offsets. However, large-scale adoption requires investments in infrastructure, education, and international cooperation. By addressing these challenges, blockchain has the potential to revolutionize energy trading, enhance trade stability, and strengthen global energy security amidst ongoing geopolitical uncertainty.

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