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Article

Critical Factors in Adopting Blockchain Technology in Value-Added Tax Systems

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ABSTRACT

Blockchain technology stands at the forefront of innovation with the potential to revolutionize Value Added Tax (VAT) systems, positioning them as key components in promoting sustainable economic development. In this study, we provide an exhaustive analysis of the diverse challenges encountered in the blockchain integration process within VAT systems, addressing technical, legal, and socio-political dimensions. We address technical challenges such as scalability, compatibility, and data migration, while also highlighting potential vulnerabilities of blockchain systems. From a legal perspective, we analyze the implications of varying data protection standards and regulations across jurisdictions, with a focus on the interplay between blockchain and established legal frameworks. Socio-politically, the study discusses the fundamental shift required in the operations and collaborative mechanisms of tax administrations. Recognizing resistance from institutional stakeholders, we propose strategies for awareness promotion, capacity-building, and organizational adaptation. By considering these multifaceted challenges, the article aims to offer insights into the strategic measures necessary for effective blockchain integration in VAT systems.

KEYWORDS: blockchain technology; tax fraud detection; international cooperation; public law; digital transformation in tax administration; sustainability in fiscal policy

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INTRODUCTION

Value Added Tax (VAT) evasion and fraud represent critical impediments to sustainable fiscal policy, with significant repercussions for the equitable distribution of resources and the stability of global economies. These illicit activities not only undermine fiscal stability but also contribute to economic disparities, leading to far-reaching consequences for societies and economies [1]. The global cost of tax

evasion is reportedly around $500 billion annually [2], highlighting the urgent need for innovative and effective strategies to tackle these tax-related challenges. One prominent contributing factor to VAT non-compliance lies within the systemic weaknesses of the existing technological frameworks, particularly their limitations in preventing, identifying, and rectifying instances of VAT evasion [3].

Despite continuous advancements in technology that provide promising solutions, academic literature lacks a systematic review on the application of emerging technologies, such as blockchain, to reduce VAT evasion and fraud [4]. This research article seeks to bridge this gap, evaluating the potential role of blockchain technology in the exchange of information between different VAT administrations and government institutions. To achieve this, the study employs a systematic literature review methodology to comprehensively analyze and discuss existing studies on the application of blockchain in reducing VAT evasion and fraud. By aggregating insights from diverse sources, this approach allows for a detailed examination of the current state of knowledge and identifies gaps where further investigation is required. This methodology not only supports the evaluation of blockchain's potential in enhancing information exchange among VAT administrations but also facilitates a critical analysis of the implications of these technologies across various governmental and institutional frameworks. Through this systematic review, we construct a cohesive understanding of blockchain's capabilities and limitations, offering a grounded basis for recommendations on its application in tax systems. The rigorous analytical framework ensures that our conclusions are well-supported by existing empirical evidence and theoretical perspectives, providing a robust foundation for the assertions made in this study.

To address the challenges of VAT evasion as identified, the application of blockchain technology presents a promising solution. As a decentralized and distributed digital ledger that records transactions across multiple computers, blockchain offers the potential to ensure immutability and transparency of registered transactions, which are crucial features for enhancing security within VAT systems. While blockchain is often associated with cryptocurrencies, its broader applications could significantly influence business operations, record-keeping, and asset transfers [5]. Blockchain's inherent characteristics—trust, traceability, and security—are pivotal in enhancing fraud detection and VAT compliance. Furthermore, the efficient exchange of information facilitated by blockchain technology could provide real-time insights into taxpayers' data, track VAT activities more effectively, and thereby enhance the security and transparency of VAT administration [6].

Building upon the exploration of blockchain's capabilities in enhancing VAT system security and compliance, this article further assesses the possible implications of blockchain technology within VAT administration. Emphasizing its potential role in facilitating information exchange among

VAT authorities, we critically discuss both the advantages and challenges associated with this technology. Our objective is to provide a detailed analysis of whether blockchain might influence transparency, the reliability of VAT collection, and the efficacy of VAT administrators in their roles. More precisely, we intend to critically examine the capacity of blockchain technology in VAT administration with particular regard to information exchange, which is essential for sustainable economic governance [7]. We seek to provide a balanced framework to help VAT authorities and stakeholders in evaluating the feasibility of integrating blockchain [8]. This work intends to offer valuable perspectives for policymakers, VAT administrators, and other stakeholders in the ongoing discourse about VAT compliance and fraud detection.

OVERVIEW OF EXISTING LITERATURE ON BLOCKCHAIN AND TAX SYSTEMS

Technological advancements have profoundly affected global politics by lowering information collection costs, mitigating market friction, and driving global market expansion [9]. Taxation is undergoing a digital transformation with growing attention towards technologies like digitalization, robotization, machine-to-machine (M2M) technologies, and notably, blockchain [10].

Building on the transformative potential of blockchain highlighted in the existing literature, it is important to recognize this technology's status as a disruptive innovation within the domain of taxation and beyond. As identified by Frizzo-Barker et al. [11], blockchain's role extends beyond mere technological advancement; it redefines business models and operational frameworks by offering unprecedented transparency, security, and efficiency. This disruption is not only reshaping the way tax administrations operate but also challenging traditional notions of accountability and governance as discussed by Marrone and Hazelton [12]. The integration of blockchain into tax systems, as evidenced in the literature, suggests a significant shift from conventional methods to more robust, fraud-resistant, and transparent practices, fundamentally altering the landscape of fiscal policies and administration. Moreover, Brennan et al. [13] further underscore the broader implications of such disruptive technologies, highlighting the necessity for evolving corporate governance structures to adapt to these technological advancements. Thus, blockchain stands not merely as a technological upgrade but as a cornerstone for the radical transformation of tax systems globally, aligning with broader economic and social shifts towards digitalization.

Several studies have explored the potential implications of these technologies on tax collection [14] and the financial burden of implementing electronic tax systems for businesses). However, these technologies also provide opportunities for improving taxpayer services, encouraging tax compliance, and developing new audit mechanisms in the age of 'big data' [15,16].

The emerging digital landscape has encouraged international cooperation for information sharing among tax authorities [17]. Technologies such as data mining, AI, and blockchain have played pivotal roles in this process, enhancing tax audits and reducing the need for face-to-face interactions, thereby potentially increasing government revenues [18,19].

In light of the transformation brought about by digital technologies, blockchain stands out as a significant innovation for its potential to revolutionize the way information is shared among different tax administrations and government institutions [6]. The decentralization, transparency, and security that blockchain provides can offer an effective solution for information exchange in tax administration, enhancing the ability to track fraudulent transactions and boost overall system transparency [20]. The use of blockchain technology can substantially contribute to the automatic exchange of information, enhancing global transparency. The technology's immutability and cryptographic security enable the secure transfer of data and information, preventing unauthorized access and manipulation. With its ability to maintain transparent and tamper-proof records, blockchain can facilitate real-time access to taxpayers' data and improve tax compliance while ensuring data security.

Yet, despite its potential, the application of blockchain in the tax domain remains nascent. The advent of blockchain technology has ushered in a new era of possibilities for combating fraud in tax administration. Few countries, such as Estonia and Dubai, have started to integrate blockchain into their tax systems [21]. Further exploration is essential to understand how blockchain can be harnessed for effective information exchange among various tax administrations and government institutions, as the body of literature on this specific application is still emerging.

Initial studies have begun to dissect the potential of blockchain technology in enhancing tax compliance and fraud detection. For example, Alkhodre, Jan, Khusro, Ali, Alsaawy and Yasar [22] proposed a blockchain-based system for VAT collection, suggesting that such a system could curb fraud while streamlining the tax collection process. The study also implied that blockchain could facilitate secure and efficient data exchange among different tax authorities. Similarly, Rajasekaran, Azees, & Al-Turjman [23] explored the application of a blockchain-based system for managing digital identities, demonstrating the technology's potential in improving taxpayer verification processes and dissuading identity-based tax fraud.

In light of the unique attributes of blockchain, such as transparency and immutability, Santos, Marinho and Bernardino [24] argued that these features could substantially fortify tax data's integrity and the robustness of compliance mechanisms. The author highlighted the potential of blockchain as a means of exchanging data securely and efficiently among different tax authorities. Santos also pointed out the need for additional

research to investigate the potential regulatory and implementation challenges associated with such a blockchain-based data exchange system.

Globally, several countries have recognized blockchain's transformative potential in tax administration and, particularly, in facilitating secure and efficient information exchange. Major economies such as the United States and China have started drafting regulations relating to digital currencies and blockchain technology [25]. Other countries including Turkey, Singapore, Austria, Canada, the United Kingdom, Germany, and Thailand, have shown an interest in this field, establishing institutions to explore this technology's benefits and its potential for information sharing among tax and government institutions [25].

Wijaya, Liu, Suwarsono, and Zhang [7] demonstrated a practical implementation by developing a blockchain-based tax model for VAT. The model demonstrated the technology's capacity to increase transparency, reduce fraud, and streamline data sharing among different tax agencies. This model could address critical challenges faced by the European Union's VAT system, where countries annually see the loss of billions due to tax evasion and suboptimal tax collection mechanisms. The 2021 VAT discrepancy, marked by the difference between anticipated and realized tax revenues, was estimated at €61 billion [26]. In response, various EU governments have adopted measures like split payment, real-time reporting, and obligatory electronic invoicing. Alongside, the complex structure of today's supply chains introduces added complications. Companies with restricted visibility into their full procurement and distribution processes may encounter unexpected VAT obligations, particularly if they cannot demonstrate their lack of knowledge about potential fraud within their supply network.

THE BLOCKCHAIN ARCHITECTURE FOR VAT RECOVERY

Tax fraud significantly impacts global economies, hindering the provision of vital public goods and services. Various strategies, including regulatory oversight, auditing, advanced technological tools like blockchain, and international cooperation, are in place to counteract this challenge [27]. Regulatory measures set strict rules for tax declarations [28] with institutions like the EU. Audits serve as pivotal tools for detecting fraud, examining financial records for discrepancies [29], albeit being resource-intensive. Emerging technologies, especially blockchain, offer innovative ways to detect fraud. Blockchain, a decentralized ledger, ensures transaction verification without central oversight, promising enhanced transparency and security [30]. This technology also promotes data interoperability among tax administrations, fostering efficient and secure data sharing [5].

In understanding the application of blockchain for VAT recovery, it is critical to distinguish between different types of blockchain architectures—public vs. private and permissionless vs. permissioned.

Public blockchains are decentralized and non-restrictive, allowing anyone to participate and view transactions, which enhances transparency but can pose challenges in terms of privacy and scalability. Private blockchains, on the other hand, restrict participation to selected members, offering greater control and privacy, which is crucial for sensitive financial information involved in VAT systems. Similarly, permissionless blockchains allow any participant to conduct transactions and participate in the consensus process without prior approval, which supports greater decentralization but may not meet the regulatory requirements for tax systems. Permissioned blockchains restrict the ability to write to ledgers to a select group of participants, combining the benefits of blockchain with necessary regulatory oversight. For VAT recovery, a permissioned and private blockchain architecture is likely more suitable as it offers the necessary privacy, security, and compliance with regulatory frameworks, ensuring that only authorized entities can access and verify the tax-related transactions. This configuration aligns with the needs for secure, transparent, and efficient information exchange among tax authorities, as discussed by O'Leary D.E. [31], who emphasizes the importance of configuring blockchain architectures to suit specific transactional and institutional requirements in accounting and supply chain systems.

While blockchain's potential in general tax fraud detection is evident, its specific applications in enhancing the VAT system are drawing significant attention in academia. A notable suggestion is the implementation of a distributed ledger that captures all VAT-related business transactions, with each transaction being promptly validated by tax authorities [32]. This method would allow for quick identification of inconsistencies and fraudulent activities. Alternative applications of blockchain could focus on recording evidence for intra-EU supplies of goods or monitoring intra-company transactions [21]. Considering the current environment of incomplete information, the evolving demands of tax administrators, and data inconsistencies, a reliable ledger that provides real-time validation appears to be a fitting solution. However, the broader tax sector has been hesitant in adopting these blockchain strategies.

On the international front, cooperation is crucial to address cross-border evasion. Initiatives such as the OECD's Automatic Exchange of Information (AEOI) encourage information sharing among nations [33], with blockchain potentially facilitating these secure exchanges [34]. In this context, blockchain technology could have the potential to play a significant role by facilitating secure, efficient, and transparent data exchanges between tax administrations and other government institutions [34]. Blockchain's inherent characteristics, such as immutability and transparency, could further increase global tax transparency and prevent asset concealment abroad.

An interesting model has been proposed by Gaie & Mueck [32] that puts forward a hybrid blockchain approach aimed at enhancing the recovery

process for VAT. This approach not only focuses on improving the efficiency and accuracy of VAT recovery but also takes into consideration the stringent privacy requisites mandated by the European General Data Protection Regulation.

The heart of this approach lies in harnessing the decentralized nature of blockchain while concurrently introducing a governing authority to oversee the operations, which strikingly cuts down power consumption without compromising transactional security. Each transaction, containing pivotal details like the identification of the buyer and seller, transaction amount, VAT collected, and transaction date, would be encapsulated within a block for security and transparency [35].

To foster this increased transparency and coordination, the National Central Bank (NCB) would act as a pivotal point, ensuring each transaction is overseen by multiple banking institutions. Each block would be dispatched to the respective NCB of the country involved, bolstering the system's reliability and security. By centralizing some elements of the process, the architecture can dramatically reduce power consumption associated with traditional blockchain validations. Every transaction block, which contains pertinent details such as buyer and seller identifications, transaction amounts, and VAT collected, is transmitted to the respective NCB. This ensures system transparency, coordination, and recovery securitization, given the independent nature of the NCB.

The novelty of this proposal lies in its mechanism, where funds could be distinctly separated: the pre-tax amount traveling from the buyer to the seller, and the VAT directly to the NCB. This approach ensures that sellers can never withhold VAT, thereby directly addressing chain evasion and carousel fraud.

The proposed hybrid blockchain model contributes to the sustainability of VAT systems by facilitating the efficiency and accuracy of VAT recovery while also reducing the carbon footprint associated with traditional transactional processes. The reduced power consumption inherent in this model not only aligns with the digital efficiency but also supports environmental sustainability objectives.

However, limitations exist. Regulatory and audit measures, although effective, are resource-intensive. Technological interventions face challenges like data privacy concerns and integration issues with legal systems.

THE LEGAL AND REGULATORY CHALLENGES OF BLOCKCHAIN INTEGRATION FOR VAT

While blockchain technology holds significant potential for streamlining information exchange and enhancing tax fraud detection, it is not without challenges and limitations. The application of blockchain technology in the context of tax administration necessitates an examination of various legal, technical, and socio-political factors [5]. From a legal perspective, the blockchain's decentralized nature, which

translates to a network spread across multiple geographic locations, could pose jurisdictional issues [36]. For instance, in a blockchain-based system facilitating information exchange between different tax administrations and government institutions, determining under which jurisdiction a dispute should be resolved could be particularly complex. This is even more prominent in an international context, where conflicting laws and regulations may apply [34].

Another significant challenge lies in the potential clash between blockchain's inherent transparency and existing data privacy regulations. Blockchain's design ensures that all transactions recorded on the blockchain are transparent and immutable, meaning they cannot be altered or deleted. While this feature increases the system's reliability and mitigates fraud risks, it can conflict with certain data protection regulations [37].

A clear example of this conflict is evident with the European Union's General Data Protection Regulation (GDPR). The GDPR grants individuals the 'right to be forgotten', enabling them to request the deletion of their personal data under specific circumstances. However, the immutability of blockchain transactions creates a paradox, as data recorded on the blockchain cannot be erased [37]. If personal tax-related information is shared via a blockchain-based network, reconciling the GDPR's provisions with the operation of the blockchain would pose a significant challenge. Blockchain's transparency could potentially expose sensitive taxpayer information, presenting a risk to privacy if not adequately controlled. While there are techniques such as "zero-knowledge proofs" that allow transaction validation without revealing sensitive information, their implementation in the context of tax data exchange might be complex and requires further research.

The prospect of a global, blockchain-based tax information exchange system raises another significant legal challenge: the potential variation in adoption across different countries due to their unique technical capabilities, legal frameworks, and political circumstances. Countries with advanced technological infrastructure and favorable regulatory environments may be better positioned to implement and benefit from blockchain-based systems, while those with weak technological infrastructure or stringent data protection laws may face significant hurdles [34]. For instance, developing countries may lack the necessary technical infrastructure or the skilled workforce required to implement and maintain complex blockchain systems. This disparity could create an imbalance in the system's effectiveness and benefits across different jurisdictions, eventually exacerbating existing global digital divide issues [38].

Moreover, the political willingness of governments to participate in such a system is crucial. Countries known for their strict data privacy laws or those that benefit from the existing tax system may resist the transparency and information sharing that blockchain facilitates. Such

resistance could undermine the cooperative nature of a global blockchain-based tax information exchange system, impeding its full potential [34].

TECHNICAL CONSIDERATIONS IN INTEGRATING BLOCKCHAIN INTO VAT SYSTEMS

On the technical front, the integration of blockchain with existing tax systems may be a complex and resource-intensive process, especially given the potential resistance from established stakeholders used to conventional systems [5]. While blockchain adeptly manages cryptocurrency transactions, its capability to facilitate fiat currency transfers remains undeveloped. This limitation restricts its immediate utility for conventional tax collection.

Merging blockchain with varied business applications poses a considerable challenge, particularly with the diversity of companies' enterprise resource planning (ERP) systems in operation. These systems vary in design, function, and data protocols. Harmonizing them within a unified blockchain framework necessitates meticulous strategy and implementation. The data migration process from existing databases to a blockchain system must be designed to prevent loss or compromise of sensitive tax data during transition [39].

Moreover, the integrity of blockchain data is only as good as its input. Inaccuracies introduced during data entry, whether unintentional or malicious, compromise the technology's credibility and reliability [40,41]. Security concerns, although reduced to some extent by blockchain's inherent features, remain a crucial consideration. While blockchain is typically more secure than traditional databases, it is not immune to cyberattacks, as demonstrated by several instances of security breaches in the cryptocurrency domain [42]. For a blockchain-based system handling sensitive tax data, robust security measures must be in place to prevent such attacks.

Blockchain's security heavily relies on cryptography, which, while currently deemed secure, could be threatened by developments in quantum computing. Quantum computers, once they reach a certain level of maturity, could potentially break today's cryptographic algorithms, posing a potential long-term security risk to blockchain systems [43].

One of the significant technical obstacles is the integration of blockchain technology with existing tax systems. This process is not just technically complex but could also be resource-intensive, requiring substantial time, financial investment, and technical expertise [44,45]. Moreover, tax authorities around the globe employ a variety of systems, many of which are national systems that may not be readily compatible with blockchain technology. Adapting these systems to work with blockchain could entail significant overhauls and involve overcoming resistance from stakeholders accustomed to traditional systems [46].

There is also the question of scalability, as the current state of blockchain technology may not be able to handle the high volumes of data

and transactions typically involved in tax administration [47]. Current blockchain technology, particularly public blockchain networks like Bitcoin and Ethereum, have been criticized for their limited transaction processing capacity [47]. Tax administration involves handling massive volumes of data and transactions, and it is imperative for any system used in this context to efficiently process these transactions. While solutions to improve blockchain scalability, such as sharding or layer-two solutions like the Lightning Network, are being researched and developed, these are still in nascent stages [48].

It must also be noticed that blockchain's decentralized architecture is ideally designed for multi-party interactions, but its efficacy for singular departmental tasks or within confined departments is yet to be determined. Its inherent structure might inadvertently add layers of complexity for isolated operations [49].

SOCIO-POLITICAL CHALLENGES IN ADOPTING BLOCKCHAIN FOR VAT

The socio-political dimension is equally critical, as the adoption of blockchain technology would necessitate a fundamental shift in how tax administrations and other government institutions operate and collaborate [50]. This transformation could face resistance from both within and outside these institutions due to vested interests, lack of awareness, and concerns about the potential disruption of existing structures and processes [51].

Moreover, the participation of different countries in an international, blockchain-based information exchange system may vary based on their technical capabilities, legal frameworks, and political will [52,53]. Countries with weak technological infrastructure or stringent data protection laws may face difficulties in adopting blockchain-based systems, eventually creating disparities in the system's effectiveness across different jurisdictions [34].

The adoption of blockchain technology necessitates a paradigm shift in how tax administrations and government institutions operate and collaborate, which inevitably introduces significant socio-political challenges. One such challenge is institutional resistance, often arising from a fear of change or concerns about the potential disruption of existing structures and processes [50].

Blockchain technology, being decentralized and inherently transparent, would radically alter the existing power structures and dynamics within and between organizations. This shift could trigger resistance from those with particular interests in maintaining the status quo, or from individuals who are averse to change due to lack of familiarity or perceived risk [5]. Effectively managing this organizational transformation would require a strategic approach, involving awareness-raising, capacity-building, and the development of new organizational cultures and processes supportive of blockchain technology [46].

Moreover, the transparent nature of blockchain could promote fair and equitable economic practices, contributing to sustainable economic development. This sustainable approach, in alignment with environmental goals and social responsibilities, may encourage broader support for blockchain adoption from stakeholders who are not only technologically and legally inclined but also environmentally conscious.

CONCLUSION AND FUTURE DIRECTIONS

The potential integration of blockchain into VAT systems presents challenges across technical, legal, and socio-political areas. Technical challenges include issues with scalability and compatibility with existing systems, while legal barriers encompass jurisdictional discrepancies and conflicts with data protection laws such as the GDPR. On the socio-political front, the decentralization and transparency inherent in blockchain technology demand significant shifts in organizational structures and dynamics. Traditional tax and governmental entities might confront challenges rooted in blockchain's transformative nature. Expected resistance could arise from both a natural wariness of change and vested interests in preserving existing operational paradigms. Moreover, the global landscape offers its own set of variables. Different countries, with their unique technological capabilities, legislative boundaries, and political motivations, might exhibit varied adoption rates, potentially leading to non-uniform system efficacy.

Building on these observations, there lies an expansive avenue for future inquiries. As blockchain's application in tax fraud detection remains in its early stages, rigorous empirical assessments and systematic explorations are essential. Such endeavors will not only validate the theoretical assertions and findings prevalent in the existing discourse but also pave the way for more nuanced understanding and advancements in this domain. Case studies of blockchain applications in tax administration, particularly those involving inter-governmental information exchange, can offer valuable insights into the real-world feasibility and effectiveness of such applications. For instance, research can examine pilot projects or early adopters of blockchain technology in tax administration to identify success factors, challenges, and outcomes associated with these implementations.

Comparative analyses could be conducted to assess the performance of blockchain-based tax systems relative to traditional ones. This research can consider various performance metrics, including the accuracy of fraud detection, traceability, time efficiency, cost-effectiveness, and the user satisfaction. Such analyses can help determine the conditions under which blockchain technology may offer significant advantages over existing methods. Experimental studies could also be conducted to test the impact of blockchain-based information exchange systems on different aspects of tax administration. For example, researchers could design controlled experiments to examine how such systems influence the

behavior of taxpayers and tax administrators, the incidence of tax fraud, and the public perception of tax fairness and transparency.

Moreover, the socio-political dynamics associated with the adoption of blockchain technology in tax administration present an interesting avenue for research. Studies could explore how various stakeholders, including government officials, tax practitioners, and taxpayers, perceive and react to blockchain-based systems. Such research could help identify potential barriers to acceptance and adoption, as well as strategies to address these barriers.

Finally, the legal and regulatory implications of blockchain-based tax systems warrant further examination. In-depth legal analysis can shed light on the potential conflicts between blockchain technology and existing laws, as well as the need for new legal frameworks to govern the use of blockchain in tax administration.

DATA AVAILABILITY

No data were generated from the study.

AUTHOR CONTRIBUTIONS

Alfonso Pellegrino designed, conceptualized and wrote the first draft of the study. Alessandro Stasi contributed by analyzing, revising the manuscript and added valuable parts especially in the legal framework challenges section.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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