

Blockchain-Based Framework for Security and Transparency in Tax Collection and Management of Digital Government

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Abstract

With the advancement of digital government construction, tax collection and management, as a crucial link in government fiscal revenue, faces challenges such as information asymmetry, data security risks, and insufficient transparency. Drawing on the characteristics of blockchain technology, this paper proposes the construction of a secure and transparent framework for tax collection and management in digital government. By analyzing the application logic of blockchain technology in tax governance, it explores its feasibility in reducing information asymmetry, enhancing data security, and improving transparency. Based on the "Enterprise-Stakeholder-Institution" three-factor model of the information ecological chain, a tax-related information platform consisting of "Block Layer-Contract Layer-Data Layer-Report Layer" is constructed. Combined with technologies such as blockchain and big data, a spiral upward tax governance framework is proposed. The aim is to provide a secure, transparent, and efficient solution for tax collection and management in the context of digital government, thereby improving tax governance performance and promoting the modernization and intelligent development of tax collection and management.

Keywords

Blockchain; Digital Government; Tax Collection and Management; Security and Transparency.

1. Introduction

With the deepening of the "Internet + Taxation" strategy, the digitalization of tax collection and management has become a core component of digital government construction. However, current tax governance still faces significant bottlenecks [1]. From the perspective of the tax-related information ecological chain, the third-party tax-related information sharing mechanism is still in its initial stage. Relevant data presents the characteristics of fragmented "information silos", with limited sharing scope, incomplete content, lack of motivation for active sharing, uneven information quality, and incomplete supporting mechanisms [2]. At the same time, tax-related information has not formed unified standards in terms of content, form, and caliber, resulting in high costs for tax authorities in the process of information acquisition, screening, and analysis, which severely restricts the value-added utilization space of tax-related information [3]. In addition, the principle-oriented nature of accounting standards and tax laws allows for a certain degree of human judgment, which not only affects the fairness of accounting information but also increases the information identification costs and tax assessment risks for tax authorities. When there is a lack of clear legal and regulatory support, tax-related information sharing often relies on non-institutionalized methods, further exacerbating issues related to collection efficiency and security.

Blockchain technology is an integrated application of distributed data storage, peer-to-peer transmission, consensus mechanisms, and encryption algorithms. Its decentralized feature can

break the limitations of traditional centralized information storage, enabling enterprises, third-party institutions, and tax authorities to participate in information maintenance as equal nodes, helping to solve the problem of "information silos" [4]. The trustless nature and asymmetric encryption technology can build a trust mechanism without the need for third-party endorsement, reducing the risks of information verification and sharing. The irreversibility and timestamp technology can ensure that tax-related data cannot be tampered with, improving the authenticity of information and the transparency of supervision [5]. Against this backdrop, exploring how to integrate blockchain technology into the tax collection and management system of digital government and build a secure and transparent framework has become an important issue to address current pain points in collection and management and promote the improvement of tax governance quality and efficiency.

Existing studies have already recognized the enabling role of blockchain in tax collection and management. Mansfield-Devine pointed out that the distributed ledger and consensus mechanism of blockchain can solve data trust issues in the commercial field, providing ideas for information verification in tax collection and management [6]. The concept of smart contracts proposed by Nick Szabo has been applied by subsequent scholars in the design of scenarios such as automatic tax declaration and tax fund transfe [7]. However, current studies still have limitations. Firstly, they do not fully align with the core requirement of "balancing security and transparency" in digital government, resulting in insufficient design for balancing data security protection with the right to know of the public/enterprises. Secondly, there is a lack of a full-chain framework covering "technology platform-governance process-institutional coordination", leading to a lack of systematic support for technology implementation.

Based on this, this paper deeply integrates blockchain technology with digital government governance theory by constructing a four-level tax-related information platform and a spiral upward governance framework. It fills the theoretical gap of blockchain in the field of security and transparency in tax collection and management, and provides a paradigmatic reference for subsequent research on technology empowerment in digital government scenarios.

2. Adaptability between Blockchain Technology Characteristics and Tax-Related Information Ecological Chain

2.1. Analysis of Core Technical Characteristics of Blockchain

Blockchain is an integrated application that combines distributed data storage, peer-to-peer transmission, consensus mechanisms, and encryption algorithms. Its core characteristics have key adaptive value for tax collection and management:

(1) Decentralization: It adopts a distributed accounting and storage model, without the need for centralized hardware or management institutions. Enterprises, third-party tax-related institutions (such as banks, customs, and industry and commerce departments), and tax authorities are all equal nodes that jointly maintain the blockchain network. This can break the centralized barriers of "information silos" in traditional collection and management and realize multi-source collaborative maintenance of tax-related information.

(2) Trustlessness: Based on asymmetric encryption technology, nodes hold private keys (for sending transaction information) and public keys (for information decryption). Transaction balance verification and transaction amount transfer are automatically completed through digital encryption verification procedures, without relying on third-party institutions for endorsement. This can avoid credit risks, liquidation risks, and information leakage risks in the centralized model.

(3) Irreversibility: Relying on the Proof-of-Work mechanism and Timestamp, a single block is generated in chronological order. Modifying the data of a block requires simultaneously

tampering with all relevant information before it, and accounting requires investment of "computational power" time costs. This makes behaviors such as tampering and fabricating tax-related data almost impossible, ensuring the authenticity of information.

(4) Encryption Security: Asymmetric encryption technology builds a secure data transmission channel, which not only supports the sharing of tax-related information among multiple nodes but also prevents unauthorized access to information through key permission control, providing technical guarantees for the security of tax-related data.

2.2. Pain Points of the Tax-Related Information Ecological Chain based on the Three-Factor Model

Drawing on the "Enterprise-Stakeholder-Institution" three-factor model, there are significant contradictions among information providers (enterprises, third-party institutions), information demanders (tax authorities), and the institutional environment (laws and regulations, sharing mechanisms) in the tax governance information ecological chain.

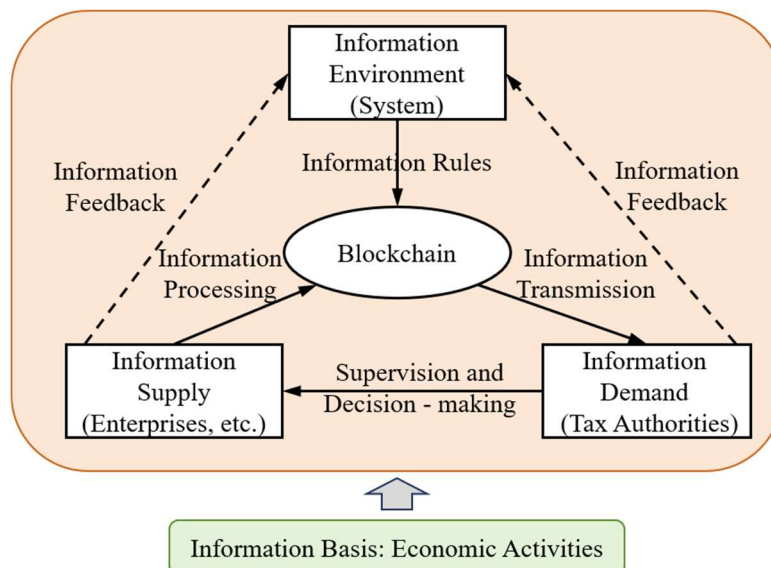


Figure 1. The "Information Provider-Tax Supervision-Institution" Three-Factor Model

(1) Information Supply Side: Tax-related information covers multi-dimensional data such as accounting, logistics, capital flow, and property rights. However, the sharing scope of third-party tax-related information is narrow, the content is incomplete, and tax-related information has not been standardized in terms of content, form, and caliber. This leads to fragmented information input by enterprises and third-party institutions, and high processing costs for tax authorities.

(2) Information Demand Side: Tax authorities have diverse information needs for tax-related information of different tax types, industries, sectors, and tax sources. However, in the traditional model, information acquisition is passive, making it difficult to extract high-quality data on demand. Moreover, the space for human judgment between accounting information and tax laws increases the costs of information identification and tax assessment risks for tax authorities.

(3) Institutional Environment Side: The sharing of tax-related information relies on strong constraints from laws and regulations. For example, after the "Tax Collection and Administration Law" clearly stipulates the data provision requirements for the Industry and Commerce Bureau, its attitude towards assisting in tax collection is significantly better than that of other units. When there is a lack of clear legal basis, the sharing mechanism often relies

on non-institutionalized methods for maintenance, and disputes over departmental interests further hinder information flow.

2.3. Adaptation Logic between Blockchain and Tax Collection and Management of Digital Government

Based on the above characteristics and pain points, the adaptability between blockchain and tax collection and management of digital government is mainly reflected in three aspects:

(1) Reducing Processing Costs: Enterprises and third-party institutions enter information as equal nodes, and rely on the blockchain node consensus mechanism to achieve information standardization, replacing traditional manual review, and improving the efficiency and consistency of information input.

(2) Reducing Identification Costs: The irreversibility and timestamp technology support the upward traceability of tax-related information, ensuring that data cannot be tampered with. The consensus mechanism reduces rent-seeking behavior, fundamentally reducing the possibility of information fraud and improving the quality of tax-related information.

(3) Reducing Sharing Risks and Costs: Through economic incentives (i.e., obtaining rewards by competing for accounting rights), the initiative of third-party information sharing is strengthened, replacing simple institutional constraints. Asymmetric encryption technology alleviates information security issues in the era of big data and reduces the risk of information leakage during the sharing process.

3. Construction of Blockchain-Based Tax-Related Information Platform

3.1. Platform Construction Logic and Core Objectives

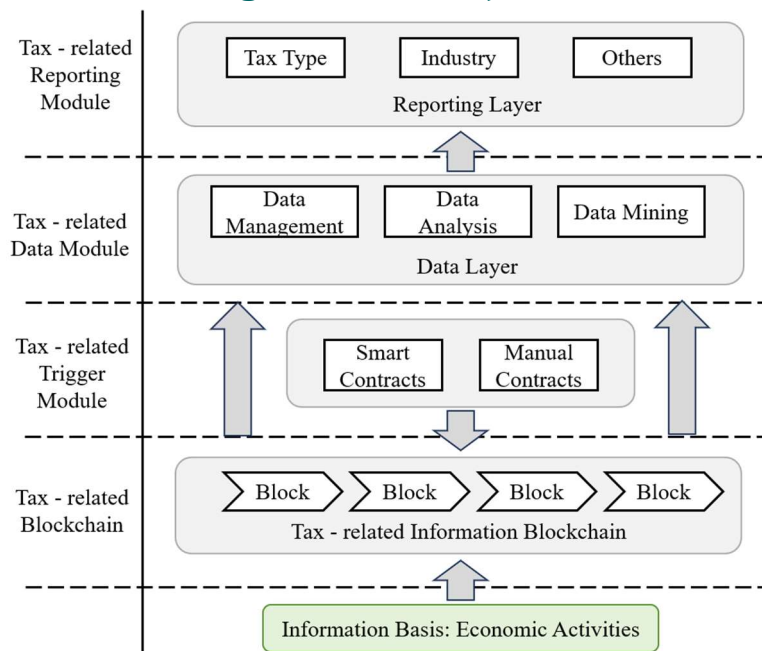


Figure 2. Construction Logic of the Tax-Related Information Platform

The core objectives of the tax-related information platform are to "restore the original appearance of economic transactions and support tax authorities in extracting data on demand". From the perspective of information flow logic, it is necessary to realize the smooth connection of "economic transaction matters-blockchain-tax authorities" and record original transaction data to ensure information quality. From the perspective of functional value, it not only needs to meet the diverse information needs of tax authorities for tax assessment and tax collection

and management but also realize the "same source" of accounting information and third-party tax-related information to improve the efficiency of information sharing.

The construction of the platform needs to solve four key issues: how to enter tax-related information into the blockchain, when to extract information, which information to extract, and how to use the information. Based on this, a four-level logical structure of "Block Layer-Contract Layer-Data Layer-Report Layer" is formed (see Figure 2). Each level is connected in sequence and progresses step by step, jointly supporting the collection, storage, transformation, and output of tax-related information.

3.2. Specific Design of the Four-Level Structure

3.2.1. Block Layer: Information Input and Basic Guarantee

Design Basis: It takes blockchain technology as the technical foundation and event accounting as the theoretical foundation. Event accounting advocates reporting economic activities based on specific economic events, which can fully record transaction details. For example, when purchasing equipment overseas, in addition to accounting information, third-party data such as foreign exchange purchase, bank capital flow, customs declaration form, logistics and transportation, and equipment information from the commodity inspection bureau can also be entered.

Core Functions: Each block records a single economic event independently, and the information forms include original materials such as text, data, and images. In the later stage, unified input standards and business codes can be set to improve the degree of information standardization and reduce subsequent sharing costs. Relying on the decentralized feature, it enables tax authorities to obtain third-party tax-related information across borders, breaking geographical and departmental barriers.

3.2.2. Contract Layer: Information Extraction Trigger Mechanism

Design Basis: It takes smart contracts as the core, supplemented by manual contracts. A smart contract is a "digitally defined commitment and execution agreement" that can be automatically executed when preset conditions are met. Manual contracts are used to deal with unconventional matters.

Core Functions: Multi-dimensional trigger conditions are set through smart contracts, covering the entire process of tax governance: In terms of tax compliance, combined with event accounting, automatic confirmation of tax obligations and automatic transfer of tax funds are realized. In terms of tax assessment, with time and tax-related indicators as trigger conditions, information is automatically extracted from the blockchain to the data layer. In terms of tax collection and management, with tax assessment results as trigger conditions, collection and management actions are automatically initiated. In terms of credit rating, with the nature of tax non-compliance as trigger conditions, the tax credit rating is automatically updated. At the same time, it supports cross-departmental collaborative supervision and allows other regulatory authorities to set trigger conditions.

3.2.3. Data Layer: Information Transformation and Value Enhancement

Core Objective: To solve the problem that the information in the block layer is "detailed but complicated and insufficiently standardized", transform the original information into concise and usable data, and at the same time enhance the value of information analysis.

Key Measures: Address the issue of unit conversion, taking into account multi-dimensional measurement methods such as currency and physical objects, in line with the requirements of accounting standards and tax laws. Draw on Extensible Business Reporting Language (EBRL) technology to realize automatic data capture and standardized arrangement. Introduce big data storage, mining, and analysis technologies to make up for the weak statistical analysis function of the block layer and improve the use value of information.

3.2.4. Report Layer: Information Output and Security Control

Core Objective: On the basis of the data layer, form targeted and easy-to-use tax-related reports, balancing "highlighted information focus" and "cost-effectiveness".

Key Designs: In terms of content, composite options are set to support tax authorities in automatically extracting data to generate reports through commands. In terms of format, a visual window layout is adopted to improve information readability. In terms of permissions, different output permissions are set according to tax types and industries to match the work needs of regulatory authorities. In terms of security, asymmetric encryption technology is used, and different keys are used for report generation and interpretation to prevent unauthorized access.

4. Blockchain-Based Secure and Transparent Framework for Tax Collection and Management

4.1. Theoretical Basis for Framework Design

The secure and transparent framework for tax collection and management takes "improving governance performance" as the core. Drawing on the concept of "embedding in core business and enhancing subject value" from the COSO Enterprise Risk Management Framework, it balances tax collection and management capabilities and costs, and constructs a "spontaneous, active, and spiral upward" governance model. Through pre-guidance (tax credit, compliance costs) and post-control (tax assessment, collection and management), a closed-loop management is formed, and ultimately, taxpayers consciously fulfill their tax obligations and tax authorities conduct efficient supervision.

Framework Performance Improvement Path: On the one hand, by increasing the cost of tax non-compliance (late fees, fines, reputation losses), the compliance of taxpayers is improved. On the other hand, blockchain technology is used to reduce supervision costs (information identification, sharing, and circulation costs), achieving the dual goals of "increasing revenue and reducing costs".

4.2. Core Links and Operation Mechanism of the Framework

The framework takes "tax compliance-tax assessment-tax credit rating-tax collection and management" as the core closed loop (see Figure 3). Each link realizes security and transparency relying on blockchain technology.

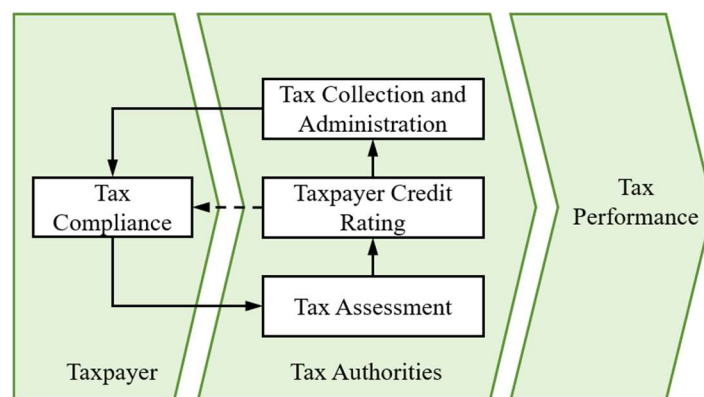


Figure 3. Framework of Tax Governance

(1) Tax Compliance: Technology Empowers Information Verification. Blockchain technology prevents false and incorrect information by improving the coincidence degree of tax-related information (mutual verification between accounting information and third-party data),

reducing information identification costs. At the same time, it increases the probability of identifying tax non-compliance: For standardized transactions (such as conventional value-added tax business), a semi-automatic compliance model can be set up to automatically calculate the tax payable and compare it with the actually paid tax amount. For personalized transactions, data differences are identified by breaking "information silos", and transaction standardization is gradually promoted, ensuring compliance effects while controlling supervision costs.

(2) Tax Assessment: Data Supports Accurate Analysis. After integrating blockchain technology, tax assessment extracts information from the block layer, converts it into assessment data through the data layer, and finally forms an assessment report. Combined with the existing risk identification process of the Golden Tax Phase III Project, the problem of connecting "information sources and destinations" is solved. Relying on big data mining technology, the in-depth processing from the data layer to the report layer is improved. A multi-dimensional assessment indicator system is established, and historical data is classified by tax type, industry, and region to form an indicator database. Linear/non-linear models are introduced to evaluate special tax obligations, improving the accuracy of assessment.

(3) Tax Credit Rating: Blockchain Ensures Authenticity and Transparency. Tax authorities enter tax non-compliance information into the blockchain based on tax assessment reports. The blockchain automatically calculates the degree of non-compliance and classifies it according to preset rules. After taxpayers correct non-compliance behaviors, the blockchain automatically updates the degree of non-compliance and credit rating to avoid human tampering. Public keys and private keys are configured using asymmetric encryption technology. On the premise of ensuring information security, credit ratings are disclosed to taxpayers' stakeholders, solving the problems of narrow sharing scope and poor effect of the traditional "blacklist" and increasing the reputation loss cost of taxpayers.

(4) Tax Collection and Management: Smart Contracts Drive Efficient Execution. Taking the results of tax assessment and credit rating as the trigger conditions for smart contracts, targeted collection and management activities are automatically initiated, the nature and causes of non-compliance behaviors are clarified, and a collection and management report is formed. Multi-level smart contracts are set in the contract layer to automatically issue collection and management tasks to responsible departments. Special tasks are coordinated across departments through smart contracts to reduce internal information circulation costs. Combined with the economic consequences of credit ratings, taxpayers are guided to self-assess their compliance status and reduce tax collection and payment games.

4.3. Synergistic Relationship between the Tax-Related Information Platform and the Collection and Management Framework

The tax-related information platform (technical layer) and the tax collection and management framework (theoretical layer) are interdependent and work synergistically (see Figure 4).

The platform provides data and technical support for the framework: the block layer ensures information authenticity, the contract layer realizes process automation, the data layer provides an analysis basis, and the report layer outputs supervision basis. The framework clarifies the application direction for the platform: around the needs of tax compliance, assessment, credit, and collection and management, it guides the functional design of each level of the platform. At the same time, both support targeted governance by tax type and industry, maintaining flexibility to avoid information redundancy and openness to connect with third-party information, forming a pattern of "technology-governance" two-way empowerment.

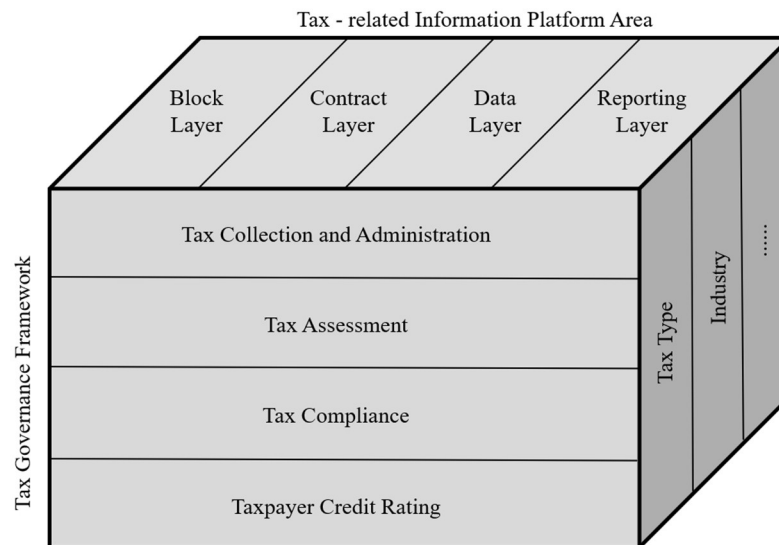


Figure 4. Tax-Related Information Platform and Tax Collection and Management Framework

5. Conclusion

Based on the characteristics of blockchain technology and combined with the security and transparency requirements of tax collection and management in digital government, this paper draws the following core conclusions:

(1) Blockchain technology can effectively address the pain points of the tax-related information ecological chain. Decentralization breaks "information silos", trustlessness reduces verification costs, irreversibility ensures data authenticity, and encryption security prevents leakage risks, providing technical support for tax collection and management.

(2) The four-level tax-related information platform of "Block Layer-Contract Layer-Data Layer-Report Layer" realizes the full-process standardization and automation of tax-related information from input to output. It can not only restore the original appearance of economic transactions but also meet the diverse information needs of tax authorities, serving as the core technical carrier of the collection and management framework.

(3) The closed-loop framework of "tax compliance - tax assessment - tax credit rating - tax collection and management", combined with blockchain and big data technologies, forms a spiral upward governance model. Through dual pre- and post-event management and control, it improves tax compliance, reduces supervision costs, and ensures the security and transparency of the collection and management process relying on technical characteristics.

Future research can further explore the integrated application of blockchain with other digital technologies, optimize the design of smart contract trigger conditions, and enhance the framework's adaptability to complex economic transactions. Meanwhile, combining practical cases, the application effects of the framework in different industries and tax types can be verified to provide more specific implementation paths for the reform of tax collection and management in digital government.

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