On the Application of Blockchain Technology in Government Procurement (Postprint)

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Abstract

Blockchain technology is hailed as the engine of the fourth industrial revolution, possessing a universal underlying technical framework that will exert influence across all industries. With the development of information technology and the continuous advancement of "Internet + Government Procurement" , the government procurement industry must likewise analyze the challenges and impacts that blockchain technology presents to the sector, and explore application prospects and applicability models.

Full Text

Abstract

Blockchain technology, hailed as the engine of the fourth industrial revolution, represents a universal underlying technical framework that will impact all industries. As information technology advances and "Internet + Government Procurement" initiatives continue to gain momentum, the government procurement sector must analyze the challenges and disruptions posed by blockchain technology and explore its application prospects and suitable models.

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Introduction

As a trending information technology topic following big data and artificial intelligence, blockchain has attracted widespread societal attention. The three fundamental characteristics of blockchain technology—decentralization, anonymity,

and immutability—make it theoretically well-suited to address existing challenges in network data sharing, such as trust costs and tampering issues. Consequently, various industries have intensified their research into blockchain applications. For instance, in August 2018, China' s first blockchain-based electronic invoice was issued at the Shenzhen Guomao Revolving Restaurant, and the Japanese government planned to register real estate and land information on blockchain-based ledgers starting in 2018. The government procurement field involves massive amounts of transaction data and information that require sharing and mining, which aligns perfectly with blockchain' s characteristics. Therefore, early research and planning on this topic are both timely and necessary.

1.1 Overview of Blockchain Technology

At its core, blockchain technology is a database system that enables universal participation in bookkeeping. Bitcoin represents its most well-known application, where each node in the network maintains a ledger of transaction records. As the name suggests, blockchain consists of "blocks" linked together in a "chain." Each node in a blockchain network uses hash algorithms and Merkle tree data structures to encapsulate received transaction data and code into a data block, which is then appended to the main blockchain to form a new block. These blocks are chronologically linked and continuously updated to maintain the ledger' s current state, thereby creating a vast and accurate information network. Blockchain is an integrated science of distributed networks, database technology, cryptography, consensus algorithms, and smart contracts. Unlike traditional databases, blockchain eliminates the need for data management institutions (decentralization), requires no verification of data falsification (immutability), and mandates that data writing be collectively approved by multiple relevant parties based on a "consensus mechanism" (trustlessness).

1.2 Advantages for Government Procurement Applications

1.2.1 Low Certification Costs Various government procurement procedures require substantial costs and resources for information verification. In open bidding processes, for example, approximately one-third of bid documents consist of enterprise qualification certifications that demand numerous official seals for confirmation. Blockchain' s decentralized characteristic enables synchronous updates of node information, reducing economic inefficiencies caused by information asymmetry.

1.2.2 Information Traceability Blockchain opens new possibilities for data tracking and information authentication. Rather than concentrating data on one or multiple computers, its structure enables every node to participate in data processing. The "block + chain + timestamp" architecture serves as proof of existence, creating immutable evidence. This ensures information security and enables attribution and accountability when information leaks occur [1].

1.2.3 Secure Trust Mechanisms Blockchain technology establishes a complete protocol mechanism that allows each node to verify the correctness of other nodes' information while recording its own, without requiring endorsement from third-party authorities. This protocol creates trust and consensus among participants. Altering information would require collusion among over 50% of nodes—a practical impossibility in large-scale blockchain applications—thereby forming a consensus-based trust mechanism.

2. Current State of Government Procurement Development

China' s government procurement scale has grown from 165.94 billion yuan in 2003 to 3,211.43 billion yuan in 2017, representing a 19.3-fold increase. In 2017, government procurement accounted for 12.2% of national fiscal expenditure and 3.9% of GDP. However, a critical issue has emerged: this rapid growth has not been matched by corresponding improvements in informatization.

2.1 Information Fragmentation

Transparency constitutes a core principle of government procurement system design, and current frameworks aim for full-process information disclosure. Nevertheless, information fragmentation remains prominent: platforms are dispersed, with no information sharing among the Ministry of Finance, various centralized procurement agencies, local public resource trading centers, and specialized websites; information is fragmented, with inconsistent content and formats in disclosed information; and data mining is insufficient, as industry data remains primarily used for basic statistics, with inadequate integration and mining of industry, product, and transaction data.

2.2 Inadequate Standardization Development

China' s government procurement standardization remains at the content level, such as regulating the content of tender announcements, pre-qualification notices, and result announcements. However, substantive implementation of electronic bidding has not been achieved, making data-level standardization impossible. For example, regarding contract announcements mandated by the Government Procurement Law Implementation Regulations, issues persist with untimely uploads, omissions, and non-disclosure, while uploaded data formats lack uniformity. Similarly, product data information from suppliers has not reached consensus across manufacturers, making integration challenging.

In April 2018, President Xi Jinping explicitly stated at the Boao Forum for Asia that China would accelerate its accession to the Government Procurement Agreement (GPA). Consequently, as government procurement opens to foreign participation, data information will inevitably face security challenges. Furthermore, despite legal confidentiality requirements, leaks in procurement evaluation

processes occur frequently, with some manufacturers filing complaints based on stolen information, making the source of leaks untraceable.

3. Application Prospects and Challenges

3.1 Application Scenarios

3.1.1 Information Sharing Platforms Blockchain-based information sharing platforms combine the advantages of traditional peer-to-peer data resource sharing and information resource centers, significantly enhancing the scope and efficiency of information exchange in government procurement. Regulatory authorities, procurers, and suppliers can use blockchain as the underlying technology to store government procurement transaction data in a blockchain-based information sharing platform. Such platforms eliminate concerns about server downtime, hacker attacks, information tampering, and high maintenance costs. Data requestors can only access data blocks securely within the platform, ensuring the integrity and availability of transaction information.

3.1.2 Information Security Massive datasets inevitably contain substantial private information. Blockchain' s privacy protection stems from its network structure. Built upon a distributed network foundation, attacks or information theft at any single node will not compromise the entire network. Whether for online transactions in electronic marketplaces or offline tendering and procurement, transaction data can be added to blocks in a unified format and protected through asymmetric encryption technology to safeguard data owners' privacy. This ensures controlled privacy when data is shared and enhances data security in big data models [2].

3.1.3 Data Value Mining The government procurement sector currently possesses tremendous potential for data mining. Mining publicly available transaction information can effectively improve budget preparation 科学性, making "exorbitant procurement" and "malicious low bidding" immediately apparent. Analyzing supplier bidding data can help identify potential "bid rigging" behaviors. Mining transaction data from procurement personnel and suppliers can prevent rent-seeking and interest transfers, contributing positively to internal controls that "prevent problems before they occur" and anti-corruption efforts that "resolutely combat corruption whenever it emerges."

3.1.4 Product Credibility The combination of data immutability and transaction traceability can resolve credit issues in procurement processes. Product traceability and anti-counterfeiting have long been procurement concerns, with suppliers devoting substantial resources to providing traceability proofs (manufacturer authorizations, agency certificates, etc.) during procurement activities. The production and logistics industries have already begun exploring blockchain technology to reliably record capital flows, logistics, and product information

flows. Under blockchain systems, the cost of fraud may exceed its potential benefits.

3.2 Challenges and Bottlenecks

3.2.1 Regulatory Positioning After Decentralization Following decentralization, how should financial departments at various levels, as rule-makers for procurement activities, position themselves? This paper argues that government procurement constitutes an important fiscal management tool, and hasty decentralization does not align with the industry' s positioning. The purpose of adopting blockchain is to leverage its ability to reduce credit costs and establish new information sharing models. Market promotion of blockchain technology must also consider this issue—not every locality requires decentralization. In fact, not all government procurement activities currently require financial department involvement; many departmental self-procurements could utilize blockchain where mutual distrust exists between procurers and suppliers, yet transactions must occur. Blockchain can resolve credit entity issues in such scenarios.

3.2.2 Relief Mechanisms After Tamper-Proofing One of blockchain technology' s greatest strengths is its tamper-proof nature. However, technology cannot address moral issues. From a technical perspective, there is no distinction between tampering and modification—erroneous operations are still operations, and malicious bidding is still bidding. The current government procurement system has a complete set of relief mechanisms that participants can initiate when they believe their rights have been harmed. For example, suppliers who believe they have been treated unfairly can question project initiators and, if dissatisfied with the response, escalate complaints to financial departments. Currently, information correction is common in government procurement activities, as errors in evaluation processes require correction and transaction data errors require recalculation. In blockchain technology, only a subsequent "tamper-proof" operation can remedy a previous one.

3.2.3 Legal and Technical Bottlenecks of Smart Contracts As a focal point in cutting-edge blockchain applications, smart contracts are computer programs deployed on blockchain that can automatically execute contract terms without requiring paper contracts with signatures and seals to become effective, as in traditional procurement activities. In the conception of Nick Szabo, who first proposed smart contracts, the initial model was procurement-related —the vending machine, which dispenses products according to established rules when money is inserted. Ideal smart contracts are considered secure and trustworthy, minimizing human intervention, but this does not guarantee perfect performance. Since smart contracts digitize contract subjects and control their transfer, vulnerabilities in contract code can lead to questionable performance. Indeed, the 2016 "DAO Incident" confirmed this: the then-largest crowdfunding

project, controlled entirely by smart contracts, was attacked by hackers exploiting contract vulnerabilities, resulting in the transfer of 3.6 million Ether and ultimately ending with the team' s resignation and project dissolution. To date, issues regarding smart contract code vulnerabilities and legal status remain unresolved.

In the current central government' s deepening reform of the government procurement system, "Internet + Government Procurement" has been elevated to an unprecedented priority. The National Institute of Standards and Technology (NIST) publication *Blockchain Technology Overview* proposes an evaluation process for blockchain adoption: the need for a database, the need for multiparty writing, and writing parties who distrust each other but share common interests. From this perspective, the government procurement industry, which remains in the early stages of digitization yet involves numerous participants, indeed exhibits high compatibility with blockchain technology characteristics. Early research and accurate assessment of its industry application scenarios are warranted.

Although blockchain technology holds broad application prospects, it remains in the initial stages of standardization and virtualization, far from achieving widespread application. Government procurement applications still face legal and technical bottlenecks, including the positioning of financial departments at various levels, relief mechanisms, and smart contracts, along with a series of risks and challenges that merit further exploration and research in the future.

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Note: Figure translations are in progress. See original paper for figures.