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Research paper

The Possibility of Using Web3 Technologies to Improve The Accounting Transparency of Government Budgets – An Analytical Study of The Opinions of A Sample of Academics and Professionals in Erbil

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Abstract

The manuscript should contain an abstract. The abstract should be self-contained and citation-free and should not exceed 300 words. The abstract should state the purpose, approach, results, and conclusions of the paper. The author should assume that the reader has some knowledge of the subject but has not read the paper. Thus, the abstract should be intelligible and complete in itself (no numerical references); it should not cite figures, tables, or sections of the paper. The abstract should be written using the third person instead of first per-son.

This study examines the potential of Web3 technologies to enhance accounting transparency in government budgets through a survey of academics and professionals in Erbil, Kurdistan Region of Iraq. A structured questionnaire with 25 statements across five dimensions was administered to 55 respondents (74.55% academics in accounting/finance, 20% professionals from the Board of Supreme Audit) using a five-point Likert scale, with data analyzed via SPSS V.27.

The empirical results extensively validate Web3's application in enhancing governmental financial transparency. Although the theoretical framework emphasized blockchain immutability as the foundation, statistical evidence revealed stronger endorsement for smart contracts (mean = 4.167) and real-time access (mean = 4.06) compared to blockchain immutability (mean = 4.047). All hypotheses were validated at a $p < 0.000$ significance level. Decentralized recordkeeping (mean = 4.12) and interoperability (mean = 4.116) also received strong support, highlighting the need for internal control and cross-government reconciliation.

The stronger support for smart contracts and real-time access reflects stakeholders' prioritization of practical, user-facing applications over underlying infrastructure. These tools offer immediate automation of budget controls, measurable cost savings, and direct citizen engage-ment—addressing urgent transparency challenges in the Kurdistan Region context more directly than blockchain's foundational security features.

From an accounting perspective, Web3 supports fundamental financial reporting principles: blockchain immutability aligns with reliability of accounting records; smart contracts function as programmed spending controls enhancing compliance and restricting unauthorized ex-penditures; real-time access corresponds to timeliness and disclosure principles, enabling continuous monitoring by citizens and oversight agencies; while decentralization and interoperability strengthen internal control and promote consistency across governmental financial sys-tems.

While blockchain provides essential recordkeeping infrastructure for transparent records, stakeholder priorities emphasize automation, accessibility, and integration. These findings suggest governmental accounting reforms should prioritize smart contracts and real-time reporting systems as primary drivers of financial transparency, with blockchain serving as the supporting foundation. The study recom-mends incremental adoption, development of real-time dashboards, integration with existing infrastructure, and establishment of supportive institutional frameworks.

Keywords: *Web3 Technologies; Blockchain; Smart Contracts; Governmental Budgets; Financial Transparency; Public Sector Accounting; Real-Time Reporting .*

1. Introduction

Governments worldwide are increasingly adopting digital innovations to strengthen public financial management and accountability. Web3 technologies—including blockchain, decentralized applications (dApps), and smart contracts—offer transformative capabilities through their core characteristics: immutability, decentralization, and automated verification. These features position Web3 as a powerful tool for various governance applications, from digital identity systems to procurement tracking and budget oversight.

Despite growing global interest, empirical evidence regarding Web3's effectiveness in public sector accounting remains limited, particularly in developing contexts such as Iraq and the Kurdistan Region. This research addresses this gap by investigating how Web3 technologies can strengthen governmental budget accountability. Through an empirical survey of academics and audit professionals in Erbil, the study analyzes stakeholder perceptions regarding Web3 implementation in governmental financial management systems, contributing evidence-based insights to support digital transformation in public finance.

2. The Methodological Framework of The Study and Some of The Literature Review

2.1. Research problem

Public sector budgets in the majority of developing economies, including the Kurdistan Region, normally suffer from persistent issues of poor transparency, inadequate disclosure practices, delayed reporting, and possibilities of data manipulation. All these frailties undermine public confidence, decrease the financial controls, and limit accountability. Though traditional accounting and auditing mechanisms have tried to restrain these issues, they are still not sufficient in an era of rapid digital growth. Recent advances in Web3 technologies like blockchain, smart contracts, decentralized apps, and interoperability solutions promise to redefine governmental fiscal reporting and enhance transparency. Empirical evidence of their potential effectiveness in public sector accounting, particularly in Iraq and the Kurdistan Region, is nonexistent. This void is the foundation of the present work.

2.2. Research objectives

The main objective of this study is to examine the extent to which Web3 technologies can improve financial transparency in governmental budgets. To achieve this goal, the study pursues the following specific objectives:

a) To evaluate the role of blockchain immutability in strengthening the reliability of governmental financial records.
b) To assess how real-time access to financial data can enhance citizens' trust in budgetary disclosures.
c) To explore the contribution of decentralized recordkeeping in reducing risks of unilateral control and manipulation.
d) To analyze the effectiveness of smart contracts in ensuring accuracy and fairness in public expenditure.
e) To investigate the impact of interoperability between Web3 applications and existing governmental accounting systems in promoting consistency and transparency.

2.3. Research significance

The present research has theoretical as well as applicative significance. Theoretically, it contributes to the expanding literature of digital transformation of public sector accounting with its linkage of Web3 technologies to the established accounting virtues of reliability, disclosure, timeliness, and financial accountability. Practically, it is of beneficial utility to policymakers, auditors, and financial managers in Iraq and the Kurdistan Region by providing an established evidence-based framework, which can aid in the building of more citizen-oriented, transparent, and credible budgeting systems. By bridging the current gap in home country research, the study not only adds to the scholarly literature but also offers pragmatic recommendations for building trust and accountability within government financial management.

2.4. Research hypothesis

This study proposes the following hypotheses:

Main Hypothesis

H0: There is no statistically significant relationship between the use of Web3 technologies and the improvement of transparency in governmental budgets.

Sub-Hypotheses

a) H0.1: There is no statistically significant relationship between blockchain immutability and the transparency of governmental financial records.
b) H0.2: There is no statistically significant relationship between real-time access to financial data through Web3 and citizens' trust in governmental financial disclosures.
c) H0.3: There is no statistically significant relationship between decentralized recordkeeping and the reduction of unilateral manipulation of governmental financial data.
d) H0.4: There is no statistically significant relationship between the use of smart contracts and the accuracy and fairness of governmental spending.
e) H0.5: There is no statistically significant relationship between the interoperability of Web3 technologies and the integration with existing governmental accounting systems to enhance transparency.

2.5. Research boundaries

a) Temporal Boundaries: The temporal scope of this research covers the period (2023–2025) during which global interest in adopting Web3 technologies for enhancing financial transparency has significantly increased. It also represents the timeframe in which the questionnaire was designed, distributed, and the data collected from the study sample. Therefore, the findings of this study reflect the perceptions and opinions of the respondents within this specific period.
b) Spatial Boundaries: The study is limited to the city of Erbil, Kurdistan Region of Iraq, which was chosen for its importance as an administrative and academic center, and for hosting professionals or employees of the Board of Supreme Audit, which plays a pivotal role in monitoring and auditing the financial activities of the public sector.
c) Population and Sample

The research sample is confined to two main groups:

- Academics specializing in accounting and finance in universities and academic institutions in Erbil.

- Professionals or employees of the Board of Supreme Audit in Erbil, given their direct involvement in auditing government budgets and reviewing official financial reports. Therefore, the results of this research represent the views of these groups specifically, regarding the possibility of applying Web 3 technologies (blockchain, smart contracts, decentralized applications, and digital wallets) to enhance accounting transparency in government budgets.

2.6. Research model

The study scheme consists of the independent variable represented in the Web3 technologies with its five dimensions (Immutability of Blockchain, Real-time Access to Financial Data, Decentralized Recordkeeping, Smart Contract Automation, and Interoperability), and the dependent variable represented by Improving transparency of government budgets.

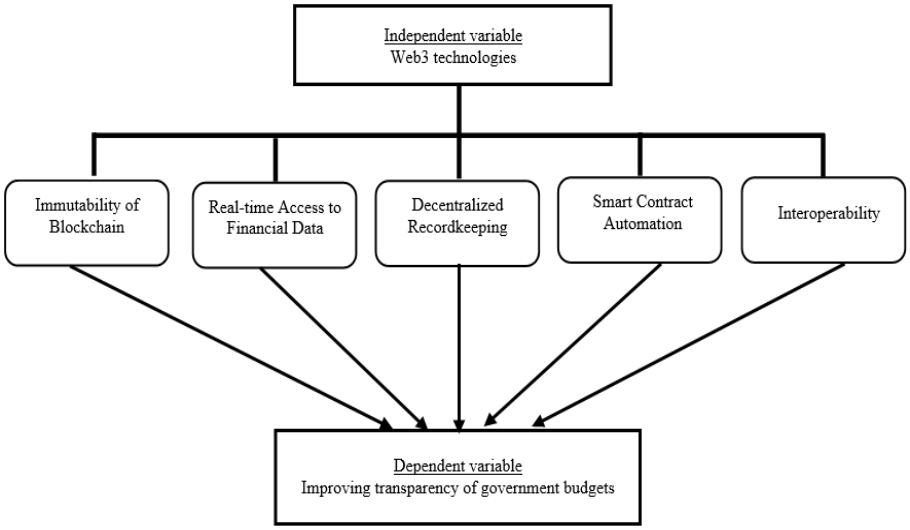

Fig. 1: Research Conceptual Model.

Source: Developed by the researchers.

2.7. Previous research and what it distinguishes from the current research

a) Mansour, R., Al-Qudah, H., & El-Ghazali, A. (2024). "A Survey on Blockchain in E-Government Services: Status and Challenges."
This study explored blockchain applications in e-government, highlighting improvements in efficiency, transparency, and trust. The authors identified major challenges: scalability, interoperability, and legal frameworks.
While Mansour et al. emphasize scalability as a barrier, this concern is less severe for governmental budgeting, where transaction volumes are modest compared to financial markets. Rahman & Patel (2024) note that private blockchain architectures adequately address public sector throughput needs. The interoperability challenge is more relevant—yet Dubai's implementations (Websima, 2024) demonstrate that API-based integration can successfully bridge blockchain and legacy systems, suggesting this is an implementation issue rather than a fundamental limitation. From a transaction cost economics view (Williamson, 1979), these challenges represent coordination costs that phased adoption strategies can mitigate.

b) Rahman, S., & Patel, K. (2024). "Blockchain Technology for Enhanced Transparency and Efficiency in Government Processes: A Systematic Review."
This systematic review (47 studies, 2019-2024) concluded that blockchain significantly improves transparency (89% of cases), efficiency (76%), and auditability (91%), while noting the need for standardized regulatory frameworks.
The high success rates may reflect publication bias favoring positive outcomes. More importantly, Rahman & Patel aggregate diverse contexts without differentiating adoption dynamics between advanced and developing economies. Their emphasis on international regulatory standardization, while valid for cross-border applications, may be less critical for domestic budget transparency where national frameworks suffice. The review examines technical outcomes but not stakeholder acceptance—our study addresses this gap by measuring which Web3 dimensions users prioritize, essential for implementations aligned with actual user needs rather than technical ideals alone.

c) Websima (2024). "Web3 and Digital Governance in Dubai: Case Studies in Public Finance."
Dubai's implementations (blockchain land registration, UAE PASS identity, smart contracts in procurement) achieved dramatic improvements: registration time reduced from 48 hours to 5 minutes, procurement delays decreased 73%.
These represent best-case scenarios in a resource-rich emirate with high digital literacy (92%) and strong institutional capacity. Transferability to developing contexts like the Kurdistan Region is limited—Dubai benefits from substantial resources, centralized governance, and a mature e-government infrastructure absent in most developing economies. From an economics of scale perspective, Dubai's UAE PASS serves 9+ million users at $0.03/transaction; smaller jurisdictions may not achieve minimum efficient scale for all applications, necessitating selective adoption of high-impact use cases.

d) Dapnet (2025). "Smart Governance: How Digital Assets Can Revolutionize Government Budgeting."
This analysis examined digital asset integration in budgeting, arguing that Web3 enables real-time tracking, reduces corruption through immutable records, and increases citizen engagement.
The digital asset (tokenization) approach introduces unnecessary volatility and legal risks unnecessary for achieving transparency goals. Real-time tracking and smart contract enforcement can be achieved through blockchain recordkeeping of traditional fiat transactions, capturing benefits without tokenization complexity—a more viable entry point for risk-averse public sectors. From behavioral economics, transparency reduces information asymmetry (Holmström, 1979), but the cognitive costs of interpreting complex data may limit engagement to educated elites unless paired with user-friendly interfaces and civic education programs.

e) Government Blockchain Association (GBA) (2025). "Tracking Government Spending with Blockchain."

U.S. pilot projects demonstrated that blockchain improved duplicate payment detection (14% increase), reduced reconciliation time (62%), and enhanced public trust (31% increase in confidence).

These pilots operated in controlled environments with dedicated support—conditions unlikely to persist at scale. The 14% improvement reflects baseline system weaknesses; jurisdictions with stronger controls may see smaller gains. The U.S. federal system's complexity creates duplicate payment risks less prevalent in centralized systems like Kurdistan's—suggesting blockchain's primary value here lies in preventing unauthorized expenditures through smart contracts rather than detecting duplicates. From institutional economics, blockchain improvements are most dramatic where traditional governance is weak, offering complementary infrastructure during institutional development.

f) Alotaibi, E.M., Issa, H., & Codesso, M. (2024). "Blockchain-Based Conceptual Model for Enhanced Transparency in Government Records."

This design science study proposed a blockchain framework for U.S. procurement agencies featuring automated data extraction, immutable storage, and role-based access controls.

The conceptual model lacks empirical validation and assumes consistent data input accuracy, technical literacy, and organizational support for transparency—assumptions that may not hold where capacity constraints, digital divides, and resistance to transparency exist. The model's automated data extraction requires ERP integration, necessitating systems modernization before blockchain deployment—a sequencing challenge for jurisdictions with outdated or paper-based processes.

g) AI Research Team (2024). "AI-Enhanced Smart Contracts for Automated Government Budget Controls."

This research explored integrating machine learning with blockchain smart contracts for real-time budget anomaly detection, reducing false-positive alerts by 78%.

AI-blockchain integration represents frontier innovation but requires extensive historical data for model training—challenging for governments transitioning from paper-based systems. AI's black-box nature may conflict with accountability requirements; auditors need to understand why transactions are flagged. This capability suits advanced adoption phases after foundational blockchain and smart contract deployment. Additionally, over-reliance on AI may create a moral hazard, with managers assuming automated oversight eliminates the need for vigilance.

h) Modern Diplomacy (2025). "How Public Finance Will Adapt to Decentralized Finance (DeFi)."

This analysis examined DeFi adaptation, highlighting programmable money (CBDCs with smart contracts), conditional transfers, and AI-driven tax analytics.

Full DeFi adoption requires digital currency infrastructure (CBDCs) not yet been deployed in most developing nations, including Iraq. DeFi's decentralization philosophy may conflict with governmental accountability structures requiring centralized oversight. The analysis is aspirational rather than immediately actionable for developing economies—Kurdistan Region can more pragmatically adopt specific Web3 elements (smart contracts, blockchain recordkeeping) within existing fiat currency frameworks before pursuing comprehensive DeFi integration.

2.8. This study makes three contributions, distinguishing it from existing literature

a) Empirical validation in developing context: Unlike case studies (Websima, Dubai; GBA, U.S.) or conceptual frameworks (Alotaibi et al.), this research employs quantitative hypothesis testing (n=55, t-tests, $p<0.000$) in a post-conflict, resource-dependent developing economy where Web3 research is absent. Our findings reveal stakeholders prioritize user-facing applications (smart contracts mean=4.167, real-time access=4.167) over infrastructure (blockchain=4.047)—a preference pattern not documented in prior literature focused on advanced economies.

b) Comprehensive Web3 assessment: Existing research examines blockchain in isolation (Mansour et al.; Rahman & Patel) or single applications (Alotaibi et al., procurement; GBA, expenditure tracking). We assess five distinct dimensions simultaneously (blockchain immutability, real-time access, decentralization, smart contracts, interoperability), providing comparative evidence on relative stakeholder priorities—essential for phased implementation strategies.

c) Interdisciplinary integration: We bridge Web3 capabilities with established accounting principles (reliability, timeliness, compliance, internal control) and economic theory (information asymmetry, transaction costs, principal-agent). This lens—absent in technically-focused prior studies—demonstrates how Web3 addresses governance failures while creating economic value through reduced monitoring costs and enhanced institutional credibility. Our integration of behavioral economics perspectives on citizen engagement and transaction cost analysis of adoption barriers extends beyond the existing literature's technical focus.

Empirical gap addressed: No prior study quantifies relative stakeholder priorities among Web3 components in governmental budgeting contexts. Our evidence that smart contracts and real-time access rank equally but higher than blockchain immutability provides actionable guidance for implementation sequencing unavailable in existing conceptual or case-based research.

3. Theoretical Aspect of Research

3.1. Introduction

There is now an urgent need for greater transparency, accountability, and public trust in financial management. Current public budget and financial reporting systems are marred by delays, dispersion, and limited accessibility, which discourage oversight and citizen engagement. New digital innovations offer the prospect of rethinking the way government financial information is recorded, monitored, and shared. Web3 technologies like blockchain, smart contracts, and dApps are a revolution toward decentralized spaces offering immutable, verifiable, and real-time accessible data. Theoretical foundations for investigating how Web3 can facilitate enhanced government budget accounting transparency are set in this chapter by including technical, institutional, and governance perspectives.

3.2. The concept and development of Web3 technologies

3.2.1. The concept of web3

a) Technical Definition

Web3 is the third generation of Internet technologies that supports decentralized peer-to-peer communication in the absence of central intermediaries. It is built on blockchain and cryptography, under which users own their data, support the execution of smart contracts, and offer engagement in digital communities with transparency and self-determination (Jiang, 2024, p. 4).

b) Functional Definition in the Government Context

Web3 is a set of new digital technologies, such as blockchain, smart contracts, and decentralized applications, that are employed to enhance transparency, security, and efficiency in electronic systems. In public finance, Web3 provides features for tracing government transactions, automation of budgeting, and the provision of time-stamped and tamper-evident financial accounts (Bisogno et al., 2022, p. 15).

3.2.2. Stages of internet development: Web 1.0, Web 2.0, and Web 3.0

a) Web 1.0 – The Static Web (1990s to early 2000s)

Web 1.0 refers to the initial generation of the internet, described sometimes as the "read-only" web. It was comprised largely of static web pages that developers wrote by hand in HTML and served as virtual brochures. Content creators only made the content, with users consuming information passively without creating or engaging (Wan et al., 2023, p. 50).

b) Web 2.0 – The Social and Interactive Web (Mid-2000s to Present)

Web 2.0 marked the transition to a more dynamic and participatory web environment. It introduced interactive platforms that allowed users to create, share, and comment on content through blogs, social media, and collaborative tools like wikis (Bisogno et al., 2022, p. 14).

c) Web3.0 – The Decentralized Web (Emerging since ~2018)

Web3 represents the "read-write-own" era of the internet, underpinned by decentralization, transparency, and user sovereignty. Powered by blockchain, smart contracts, and distributed ledger technologies, Web3 enables individuals to own their data and participate in decentralized governance structures without reliance on centralized authorities (Jiang, 2024, p. 4).

3.2.3. Web3's core characteristics: decentralization, immutability, and automated verification

a) Decentralization

In contrast to traditional centralized platforms, Web3 operates on decentralized networks, meaning no single entity controls the system. Transactions are validated by a network of participants (nodes), increasing system robustness and reducing the potential for manipulation or censorship. This is particularly beneficial for government budgeting systems, where decentralization prevents the unilateral alteration of records and enhances citizen trust (Wan et al., 2023, p. 52).

b) Immutability

One of the most powerful features of blockchain—the underlying layer of Web3—is immutability. Once data is recorded on the blockchain, it cannot be changed or deleted without consensus. This ensures a tamper-proof audit trail of transactions, making it ideal for public sector financial reporting, where data integrity and historical accuracy are essential (Jiang, 2024, p. 5; Alexopoulos et al., 2019, p. 84).

c) Automated Verification (via Smart Contracts)

Smart contracts enable automated verification of conditions and execution of financial processes. In budgeting contexts, they can ensure that funds are disbursed only when predefined criteria are met—such as verified project milestones or third-party approvals. This removes human error and bias, enhances efficiency, and supports real-time oversight (Hardwick et al., 2018, p. 662).

3.2.4. The concept of Web3 and its core technologies in the context of government budgeting

The development of the internet has brought forth Web3—a decentralized and community-led paradigm that holds revolutionary potential across numerous sectors, including public finances. Web3 is informally described as the third version of the internet, where control from centralized authorities moves to distributed networks led by communities. The shift enables more transparency, data ownership, and trust, which are fundamental elements in the management and oversight of government budgets (Jiang, 2024, p. 5).

Compared to previous models of the internet, Web3 is premised on a collection of technologies that enable decentralization, automation, and secure tamper-evident data storage. In the government sector, these technologies are particularly relevant, where fiscal transparency and accountability are often compromised by bureaucratic secrecy and central control (Bisogno et al., 2022, p. 15).

3.2.5. Blockchain: distributed ledger mechanism and data security

Blockchain is the underlying technology behind Web3. Blockchain refers to decentralized ledger technology (DLT) used to record transactions on a network of computers (nodes) where every node has visibility to an identical immutable data. Compared to centralized databases, blockchain does not employ a central point of control, thereby reducing the threat of data manipulation and single-point failure (Jiang, 2024, p. 3).

In government budgeting, blockchain can be utilized to record every transaction related to revenues and expenditures in a transparent and verifiable way. Every block in the chain contains a timestamp, details of transactions, and a digital hash of the previous block, to maintain chronological integrity of the records. The architecture ensures that once written, financial data cannot be altered in hindsight, thus enhancing auditability and compliance (Alexopoulos et al., 2019, p. 84).

Aside from that, blockchain technology may be said to secure data even further by applying cryptographic consensus techniques such as Proof of Work (PoW) or Proof of Stake (PoS), which authenticate the legitimacy of each transaction before it is added to the ledger.

3.2.6. Smart contracts: automating financial processes

Smart contracts are computer programs installed on a blockchain that run automatically when set conditions are met. They eliminate the middleman by placing business logic in lines of code (Hardwick et al., 2018, p. 660).

In public budgeting, smart contracts can be utilized to automate repetitive processes such as payment of funds, conditional payment, or milestone-based project financing. For instance, a smart contract could pay out public funds only if a third party confirms the attainment of a specific step of a construction project. This minimizes human discretion, time lag, and enhances precision and fairness in public spending (Hardwick et al., 2018, p. 662).

To further clarify, although smart contracts are transparent and immutable once deployed, they provide an enforceable and verifiable record of public financial obligations and responsibilities.

3.2.7. Decentralized applications (dapps): user interaction and transparency

Decentralized applications, or dApps, are software platforms that run on blockchain networks rather than centralized servers. They allow end-users—including citizens, auditors, and policymakers—to interact directly with financial data, smart contracts, and government services in a decentralized manner (Aufiero et al., 2024, p. 208).
In the field of public budgeting, decentralized applications can be designed as interactive dashboards that:
a) Display budget allocations and spending in real-time
b) Allow citizens to comment or provide feedback on expenditures
c) Provide visualizations of financial performance metrics
d) Enable participatory budgeting or voting on funding priorities
e) These platforms enhance public engagement and trust by making government financial processes more visible, interactive, and accessible.

Furthermore, the tamper-resistant nature of blockchain infrastructure ensures the reliability of the information provided by decentralized applications.

3.2.8. Digital wallets: managing digital identities and transactions

Digital wallets are essential Web3 tools that allow users to manage their identities and conduct transactions securely through public-private key cryptography. Each wallet is associated with a unique address and is used to sign transactions, access smart contracts, and interact with dApps without revealing sensitive personal information (Wan et al., 2023, p. 53).
In government financial systems, digital wallets can serve as digital identities for both institutional actors and individual citizens. For instance:
a) Government agencies can use wallets to authorize and track disbursements
b) Auditors can verify compliance via authenticated access logs
c) Citizens can use wallets to engage in transparent civic actions such as participatory budgeting or grievance submissions

Digital wallets, combined with decentralized identifiers (DIDs), support secure authentication while preserving privacy—an essential requirement in digital public service delivery (Wan et al., 2023).

3.3. Transparency in government budgeting

Transparency in government budgeting is widely regarded as a cornerstone of good governance and public financial management. It refers to the openness, accessibility, and clarity of information related to the generation, allocation, and use of public resources. In the context of Web3 technologies, transparency takes on a new dimension, as digital tools have the potential to radically transform how budgetary information is recorded, monitored, and shared. IMF (2019), OECD (2021)
2.5.1. Definition of transparency and its dimensions in the governmental context. Transparency in public finance refers to the extent to which citizens, oversight institutions, and other stakeholders can access, understand, and monitor budget-related information. The International Monetary Fund (IMF) defines fiscal transparency as "the openness of government with respect to its fiscal policy intentions, public sector accounts, and fiscal projections" (IMF, 2019, p. 7). There are several key dimensions of transparency in a governmental context:
a) Procedural Transparency: Openness in how budget decisions are made, including participatory processes and clear legislative rules.
b) Financial Transparency: Timely disclosure of comprehensive budget data, including expenditures, revenues, debts, and obligations.
c) Operational Transparency: Actual implementation of the budget and how effectively financial plans are executed.
d) Institutional Transparency: Clarity of roles and responsibilities of government agencies and institutions in the budgeting process (OECD, 2021, p. 19). IMF (2019, p.7); OECD (2021, p.19)

3.3.1. The importance of transparency for accountability and public trust

Transparency is not merely an administrative requirement; it plays a crucial role in strengthening accountability, enhancing public participation, and fostering trust in public institutions. When citizens have access to budget data and can understand how public funds are used, they are empowered to hold governments accountable for their performance and financial decisions (Khagram, Fung & de Renzio, 2013, p. 45).
Some of the key benefits of transparency in budgeting include:
a) Enhanced Accountability: Clear reporting allows audit institutions and civil society to detect mismanagement, corruption, or inefficiencies.
b) Informed Public Debate: Open access to fiscal data enables researchers, journalists, and citizens to participate meaningfully in debates about public priorities.
c) Trust Building: Transparent processes build public confidence and reduce suspicion or misinformation regarding government spending.
d) Efficiency and Equity: When budgetary processes are exposed to scrutiny, resources are more likely to be allocated efficiently and equitably.

Moreover, transparency has become a global norm through initiatives such as the Open Budget Index (OBI) and international standards like the IMF's Fiscal Transparency Code. Khagram, Fung & de Renzio (2013, p. 45)

3.3.2. Challenges and problems in traditional reporting systems

Despite joint global efforts at increasing transparency, the majority of countries still face significant challenges towards openness in their budget processes, especially under traditional reporting frameworks. These systems are usually linked with centralization, obscurity, and inefficiency, which are against the roles of transparency and accountability (OECD, 2017, pp. 15–18; World Bank, 2018, pp. 21–24; Schäfer & Varone, 2021, pp. 130–134).
Key challenges include:
a) Data Fragmentation: Budget information is typically in disparate, non-consolidated systems and can't be easily utilized to obtain an integrated and timely picture of government finance (OECD, 2017, pp. 15–18).
b) Non-Real-Time Access: Traditional systems typically produce static reports that do not reflect real-time implementation of the budget or status (World Bank, 2018, pp. 21–24).

c) Technicality of Budget Documents: Budget documents are technical, complicated, and difficult for common citizens to understand (OECD, 2017, pp. 16–17).
d) Inadequate Public Participation: The financial decision-making process and budget process take minimal or no input from the general public (World Bank, 2018, pp. 22–23).
e) Ineffective Monitoring Institutions: Monitoring and audit institutions have poor capacity or lack independence and thus cannot effectively verify and examine budget data (Schäfer & Varone, 2021, pp. 131–133).

These challenges underscore an urgent need for modernization and innovation of budget reporting systems in the present era. Emerging technologies like blockchain and smart contracts have tremendous potential by facilitating real-time monitoring, automated auditing, and safe data sharing—features that enhance transparency beyond the limits of traditional systems (Schäfer & Varone, 2021, pp. 132–134). (Bisogno et al., 2022, p. 13).

3.3.3. The role of web3 technologies in enhancing transparency

Web3 technologies offer transformative potential for public sector accountability, especially in government budgeting. By leveraging decentralized and automated digital infrastructures, Web3 tools such as blockchain, smart contracts, decentralized applications (dApps), and real-time data systems can help governments achieve higher levels of fiscal transparency, reduce corruption, and enhance public trust (Tapscott & Tapscott, 2016, p. 45).

3.3.4. Blockchain and the integrity of financial records

Blockchain is a distributed ledger technology that records transactions in a secure, transparent, and immutable manner. In government budgets, blockchain guarantees the integrity of financial records by ensuring every entry is time-stamped, cryptographically secured, and visible to authorized stakeholders.

Key benefits include: (Tapscott & Tapscott, 2016, p. 47).

a) Tamper-Proof Record Keeping: Data on the blockchain cannot be altered or deleted without consensus, making it resistant to fraud and manipulation.
b) Auditability: Transactions can be traced and verified historically, allowing auditors and citizens to track fund allocations.
c) Distributed Verification: Decentralized validation of financial data increases trust in public reporting.

This ensures a single source of truth for financial data, reducing discrepancies and making misreporting difficult.

3.3.5. Automating and monitoring public spending via smart contracts

Smart contracts are self-executing agreements with terms written in code. In government budgeting, they automate financial processes such as disbursements, procurement, or subsidies based on predefined rules.

Applications include: (Catalini & Gans, 2016, p. 12)

a) Conditional Spending: Funds are released only when specific conditions are met, e.g., project milestones or third-party verification.
b) Elimination of Manual Errors: Automation reduces human intervention, limiting mismanagement risk.
c) Real-Time Monitoring: Live tracking of expenditures as smart contracts execute.

By reducing bureaucracy and enforcing rules, smart contracts improve transparency and efficiency.

3.3.6. Oversight of real-time citizen engagement through decentralized applications

Decentralized applications (dApps) provide interfaces on blockchain networks, enabling citizens and stakeholders to interact with government systems. They increase civic engagement and oversight by:

a) Participatory Budgeting: Voting on allocations or monitoring progress through blockchain platforms.
b) Live Notifications: Alerts on fund transfers, project starts, or account changes.
c) Public Feedback: User comments, complaints, and misuse reporting, creating accountability loops.

This reduces the distance between government and public, increasing transparency, legitimacy, and trust (Zambrano & Corduneanu, 2020, p. 102).

3.3.7. Real-time access to public financial data

Traditional budgeting systems suffer from delayed, limited access to financial information. Web3 platforms enable real-time access to government financial data through blockchain and APIs.

Advantages include:

a) Instant Reporting: Up-to-date records accessible to citizens and watchdogs.
b) Dynamic Dashboards: Interactive displays of revenues, expenses, and goals.
c) Early Irregularity Detection: Immediate flags on anomalies, aiding anti-corruption efforts.

Real-time access empowers public scrutiny and timely interventions (World Bank, 2021, p. 78).

3.4. Theoretical perspectives supporting Web3 adoption

Integration of Web3 technologies into government budgeting aligns with public administration and governance theories emphasizing accountability, transparency, and performance, including Public Value Theory, New Public Management (NPM), and governance principles (Moore, 1995, p. 23; Hood, 1991, p. 45; OECD, 2021, p. 12; UNDP, 2020, p. 34).

3.4.1. Public value theory and the role of web3 in enhancing transparency and efficiency

Public Value Theory stresses that public institutions generate value through legitimacy, accountability, and citizen trust. Web3 contributes by enhancing transparency, increasing efficiency through automation, and enabling participation via decentralized platforms (Moore, 1995, p. 26).

3.4.2. New public management and digital governance transformation

New Public Management (NPM) promotes managerial accountability, performance measurement, and private-sector practices in public administration. Web3 aligns by automating processes, enabling real-time monitoring, and encouraging innovation through digital tools (Hood, 1991, 48).

3.4.3. Linking governance principles to web3 characteristics

Web3 supports governance principles: transparency via immutable ledgers; accountability through smart contracts; participation by decentralized applications; integrity via cryptography; and rule of law by programmable enforcement (OECD, 2021, p. 15; UNDP, 2020, p. 37).

3.4.4. Conceptual model for web3-based transparency in government budgeting

Based on the reviewed literature and the identified research gaps, the researchers propose a conceptual model that demonstrates how Web3 technologies could transform the preparation, execution, and monitoring of government budgets into a transparent, verifiable, and participatory process. The model consists of four interconnected stages, each supported by specific Web3 components: data input, verification, display, and feedback.

3.4.5. Data input

The first stage emphasizes the recording of budgetary data, including revenues, expenditures, and project allocations. Traditionally, these processes rely on centralized databases, which are prone to manipulation and limited in public accessibility. The researchers propose that such information be kept on blockchain ledgers for reasons of immutability, transparency, and verifiability. This reduces corruption, illegal tampering and builds more public trust significantly.
Link to Hypothesis H0.1: This stage directly supports H0.1, which posits that the immutability feature of blockchain is positively associated with transparency in public financial records. By storing budget data on blockchain, the model ensures that records cannot be altered, thereby validating this hypothesis.

3.4.6. Verification

In the second stage, the proposed model incorporates smart contracts to automatically validate budget transactions. For instance, if an expenditure exceeds the allocated limit, the smart contract rejects it without human intervention. This automated verification strengthens accountability, minimizes opportunities for fraud, and ensures compliance with fiscal regulations.
Link to Hypothesis H0.4: The use of smart contracts in verification aligns with H0.4, which states that smart contracts improve the accuracy and fairness of government spending. Automated enforcement reduces human error and potential bias.

3.4.7. Display

The third step entails making the financial data publicly accessible. Decentralized applications (dApps) are employed as platforms through which citizens, auditors, and other stakeholders can observe expenditures in real-time. The blockchain foundation ensures that the data provided is consistent, up-to-date, and unaltered. The authors emphasize that this stage translates budgets from cryptic technical reports into dynamic instruments of public accountability.
Link to Hypothesis H0.2: Providing real-time access through dApps addresses H0.2, which posits that real-time access to financial data via Web3 platforms increases citizen trust in budget disclosures. Interactive dashboards make financial information immediately visible and understandable to all stakeholders.

3.4.8. Feedback

Finally, the model includes participatory elements through digital identities (DIDs). Authorized citizens are able to provide feedback, participate in consultations, or vote for budget priorities. The researchers assert that this participatory layer generates trust, boosts civic engagement, and intertwines social accountability into the very budget cycle.
Link to Hypothesis H0.3: Decentralized recordkeeping combined with participatory feedback mechanisms supports H0.3, which states that decentralized recordkeeping reduces the risk of unilateral manipulation of financial data. Citizen interaction adds a layer of oversight.

3.4.9. Synthesis of the proposed model

The theoretical design built by researchers envisions a transformation of opaque, centralized, and bureaucratic budgeting systems to open, automated, and citizen-led systems. All Web3 components play specific roles:

a) Blockchain offers immutability and transparency.
b) Smart contracts offer automated enforcement of compliance.
c) Decentralized applications (dApps) provide accessible and real-time visualization.
d) Digital identities (DIDs) offer participatory feedback and control

The model therefore illustrates that Web3 technologies are not just technical innovations but also functional facilitators of government budget transparency, accountability, and trust. The technologies offer immutable record mechanisms, automated compliance, real-time public access, and secure citizen interaction, leading to enhanced transparency, accountability, civic participation, and institutional trust.
Link to Hypothesis H0.5: The integrated framework of blockchain, smart contracts, dApps, and DIDs ensures interoperability with existing public accounting platforms, directly supporting H0.5, which posits that interoperability of Web3 systems facilitates integration with existing governmental accounting platforms, enhancing overall transparency.

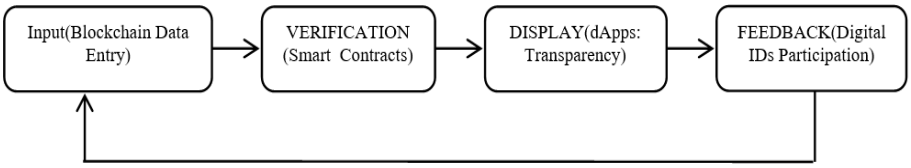

Fig. 2: Schematic Diagram of the Conceptual Model.

Source: Prepared by the Researchers.

3.4.10. Challenges and opportunities of adopting web3 in the government sector

While Web3 presents transformative potential, the researchers acknowledge that several challenges and opportunities must be addressed. Blockchain and decentralized applications enhance transparency and accountability by producing immutable records and enabling distributed oversight.

Challenges include:

a) Technical Complexity – Web3 systems require advanced expertise and substantial investment in digital infrastructure. Integration with existing governmental legacy systems can be complex, potentially delaying large-scale deployment.
b) Regulatory and Legal Uncertainty – The decentralized nature of Web3 may conflict with hierarchical administrative structures and lack clear legal frameworks for data ownership, smart contract liability, and cross-border data flows. Without updated legislation, adoption may remain fragmented or limited to pilot programs.
c) Digital Inclusion – Participatory budgeting relies on access to digital platforms and digital literacy. Marginalized groups may face exclusion, potentially exacerbating social inequalities.

Opportunities include:

a) Enhanced Citizen–State Interaction – Real-time monitoring of expenditures strengthens civic trust.
b) Automated Compliance – Smart contracts reduce bureaucratic inefficiencies.
c) Improved Data Accessibility – dApps make public data more accessible to researchers, auditors, and citizens.

Although the adoption of Web3 in the public sector is still emergent, it offers governments an unprecedented opportunity to develop more transparent, efficient, and participatory budgeting processes.

4. The Practical Aspect of The Research

4.1. Analysis and interpretation of survey results(description of the study sample and data collection)

This study examines the potential of Web3 technologies to enhance accounting transparency in government budgets through a structured survey conducted among academics and professionals in Erbil, Kurdistan Region of Iraq. A total of 55 respondents participated in the study, comprising 74.55% academics specialized in accounting and finance, 20% professionals affiliated with the Board of Supreme Audit, and the remaining 5.45% representing other related professional categories.

Participants were selected using a purposive sampling method, ensuring the inclusion of individuals possessing relevant expertise in financial transparency, public sector accounting, and emerging digital technologies. This approach was designed to capture informed perspectives from those directly involved in the areas most relevant to the research problem.

The researchers prepared a structured questionnaire consisting of two main parts. The first part contained personal and demographic variables, including job title, academic qualification, and years of experience. The second part consisted of 25 statements distributed equally across five analytical dimensions, each reflecting a specific aspect of Web3's role in enhancing transparency in government budget accounting.

These five dimensions were coded as follows: "(W1.1-W1.5), (W2.1-W2.5), (W3.1-W3.5), (W4.1-W4.5), (W5.1-W5.5) "As a group, they were coded with the symbol "(W1), (W2), (W3), (W4), (W5)" respectively.

Each item was measured using a five-point Likert scale ranging from (1) Strongly Disagree to (5) Strongly Agree, providing a quantitative measure of respondents' perceptions. This scale facilitated the statistical analysis of attitudes and allowed the identification of central tendencies across the five dimensions.

The questionnaire was distributed electronically via Google Forms to the identified research community of academics and professionals in accounting within Erbil city. Upon completion, a total of 55 valid responses were received and included in the analysis.

Data collected from the questionnaire were analyzed using the Statistical Package for the Social Sciences (SPSS) version 27, which enabled the researchers to conduct descriptive and inferential statistical tests to achieve the research objectives and verify the proposed hypotheses.

The diversity of the sample in terms of profession, educational qualification, and years of experience provides a balanced foundation for analyzing perceptions and ensures that both academic and practical viewpoints are adequately represented. This comprehensive demographic profiling enhances the representativeness and generalizability of the findings, offering insights applicable to similar professional and institutional contexts. The table below represents the variables of the questionnaire:

Table 1: Variables of the Questionnaire

Research Variables		Symbols Used	
		Dimension	Statement
Part One (Personal Information)	Participant Profession, Certificate, Years of Work Experience,	----------	
Part Two (Research Dimensions)	The immutability of blockchain contributes to enhancing transparency in public financial records	W1	W1.1-W1.5
	Instant access to financial data through Web3 platforms enhances citizens' trust in budget disclosures.	W2	W2.1-W2.5
	Decentralized record-keeping limits the possibility of unilateral manipulation of financial data	W3	W3.1-W3.5
	The use of smart contracts contributes to improving the accuracy and fairness of government spending.	W4	W4.1-W4.5

	The interoperability of Web3 systems supports integration with current public accounting platforms, thereby enhancing overall transparency.	W5	W5.1-W5.5

Source: Prepared by the researchers based on the results of the statistical analysis

4.2. Tests used before conducting statistical analysis

4.2.1. Testing the normal distribution of opinion scores according to the research axes

To test the normal distribution in this study, the Kolmogorov-Smirnov test was used (Corder, 2020, pp. 66-69). From the test results, we find that the five axes are normally distributed, meaning they are free of outliers and extreme values. This is based on the test's statistical significance level, as all values were greater than the significance level assumed by the current field study, which is 0.05. On this basis, we accept the hypothesis that the data for the study axes are normally distributed, as shown in Table 2.

Table 2: Kolmogorov–Smirnov Normality Test for the Questionnaire Dimensions

Research Dimensions	Test Value	Significance Level	Result
W1	0.077	0.142	Follows Normal Distribution
W2	0.048	0.157	Follows Normal Distribution
W3	0.083	0.092	Follows Normal Distribution
W4	0.064	0.153	Follows Normal Distribution
W5	0.071	0.154	Follows Normal Distribution

Source :Prepared by the researchers based on the results of the statistical analysis.

4.2.2. Validity and reliability of the study's axes

The validity of the questionnaire means ensuring that it will measure what it was designed to measure (Al-Assaf, 1995, p. 429). Validity also means "the questionnaire's comprehensiveness of all the elements that must be included in the analysis, on the one hand, and the clarity of its phrases, on the other hand" (Obeidat, 2001, p. 179). Such that it must be understandable to all who use it, whether the respondents or those involved in the field study. The validity and reliability of the study tool were confirmed, as shown below:

a) Validity of the internal consistency of the questionnaire's phrases according to the research axes:

This was done by calculating the correlation coefficients between the degree of opinions for each phrase and the total score (Al-Ali, 2020, p. 97). According to the research axes, the internal consistency of the questionnaire's phrases was calculated based on the sample in the current field study, which amounted to 55 respondents. Table (3), which shows the values of the correlation coefficients and the level of statistical significance for each phrase, is shown. The overall score for the axis, according to the five axes included in the study.

It was found that all statements had statistically significant correlation coefficients with the overall score for the axis (each axis separately). This was based on the significance levels of the correlation coefficient values for all statements, which were lower than the significance level assumed in the current study, which was 0.05. Therefore, all statements are considered valid for what they were intended to measure in each of the study's axes.

Table 3: Internal Consistency Validity of the Study Dimensions

Dimension	Statement	Correlation Coefficient	Significance Level	Dimension	Statement	Correlation Coefficient	Significance Level
	W1.1	.463**	0.000		W3.1	.689**	0.000
	W1.2	.472**	0.000		W3.2	.754**	0.000
W1	W1.3	.519**	0.000	W3	W3.3	.684**	0.000
	W1.4	.754**	0.000		W3.4	.420**	0.001
	W1.5	.506**	0.000		W3.5	.367**	0.006
	W2.1	.368**	0.006		W4.1	.590**	0.000
	W2.2	.334*	0.013		W4.2	.617**	0.000
W2	W2.3	.851**	0.000	W4	W4.3	.371**	0.005
	W2.4	.782**	0.000		W4.4	.465**	0.000
	W2.5	.833**	0.000		W4.5	.424**	0.001
	W5.1	.602**	0.000				
	W5.2	.476**	0.000				
W5	W5.3	.834**	0.000				
	W5.4	.307*	0.023				
	W5.5	.491**	0.000				

**: Correlation is statistically significant at the 0.01 level.

*: Correlation is statistically significant at the 0.05 level.

Source: Prepared by the researchers based on the results of the statistical analysis.

b) Research Instrument Stability:

The reliability of the research instrument means ensuring that opinions and answers will be approximately the same if it is repeatedly applied to the respondents or to members of the research sample at a number of different times (Al-Assaf, 1995, p. 430). The split-half method was applied, and through this method, the Pearson correlation coefficient was calculated between the average of the odd-numbered questions and the average of the even-numbered questions, according to the phrases and the five research parameters. The correlation coefficient was corrected, which is calculated using the Spearman-Brown correlation coefficient (Al-Ali, 2020, p. 87). The results were obtained, as shown in Table 4, where it became clear that the Spearman-Brown correlation coefficient values were statistically significant, i.e., they were statistically significant, based on the statistical significance level values, which were all less than the assumed significance level of 0.05. This indicates the reliability of the questionnaire tool, whether for the five axes or for all phrases.

Table 4: Split-Half Reliability Results for the Research Dimensions

Research Dimensions	Number of Statements	Correlation Coefficient (Before Correction)	Corrected Correlation Coefficient	Significance Level
W1	5	0.550	0.710	0.000
W2	5	0.579	0.733	0.000
W3	5	0.693	0.819	0.000

W4	5	0.585	0.738	0.000
W5	5	0.638	0.779	0.000
All Questionnaire Statements	25	0.586	0.739	0.000

Source: Prepared by the researchers based on the results of the statistical analysis.

4.2.3. Statistical methods and tools used

A set of statistical methods and tools was used using the Statistical Package for Social Sciences (SPSS IBM V.27) to develop indicators aimed at achieving the current research objectives and testing its hypotheses. These tools and methods include the following:

a) Normal distribution test: The Kolmogorov-Smirnov test was used to examine data and opinion scores for the presence or absence of outliers and extreme values (abnormal opinions) for the study themes. It is also a prerequisite for using parametric tests (Corder, 2020, pp. 66-69).
b) To ensure the validity of the internal consistency of the statements and the reliability of the research instrument, the researcher used the split-half method by testing the correlation between odd and even questions and then correcting the aforementioned correlation coefficient using the Spearman-Brown correlation coefficient (Al-Ali, 2020, p. 97).
c) The methods and tools used to describe the research variables include frequency distributions, percentages, arithmetic means, standard deviations, and finally, the use of the percentage of agreement and the coefficient of variation to determine the percentage of agreement and significance regarding a variable or axis, as well as to determine the degree of homogeneity of opinions for each statement, as well as for the axis as a whole, based on the opinions of the research sample (Al-Qadi, 2003, pp. 53-90).
d) Using the t-test in the case of a single sample. This test is used to examine whether the mean of a variable for a single sample equals a constant value (hypothesis) (Tama, 2010, pp. 81-90). In this research, the aforementioned test was used to test the validity of the researchers' claims, which were formulated in the form of the main and sub-hypotheses of the research.

The test hypothesis used is divided into two hypotheses: the null and the alternative. The null hypothesis states that there are no statistically significant differences between the hypothetical mean (3), based on the five-point Likert scale used, and the mean of the opinions according to the axis. In other words, opinions tend toward neutrality. The alternative hypothesis states that the direction of opinions and responses is toward agreement or disagreement (either if the arithmetic mean of the axis is greater than the hypothetical mean (agreement), or vice versa, indicating disagreement (rejection). We accept the hypothesis if the significance level value is less than or equal to the assumed significance level, which is usually 0.05. We infer the direction of opinions based on the test signal. If it is positive, this indicates that opinions tend toward agreement, and vice versa.

4.3. Description of research variables

4.3.1. Description of personal data

a) Distribution of Respondents by Job Title

To distribute the respondents by job title, Table 5 was used. It was found that the majority of those participating in the field study were academics, with a participation rate of 74.55%. Professionals ranked second, with a contribution rate of 20%. Finally, it was found that the lowest percentage of respondents and participants in the current study had unknown job titles, with a small percentage of 5.45%.

Table 5: Distribution of Respondents According to Participant Profession

Variable Categories	Academic	professional	Other	Total
Frequency	41	11	3	55
Percentage	74.55%	20.00%	5.45%	100%
Ranking According to Participation	1	2	3	

Source: Prepared by the researchers based on the results of the statistical analysis.

b) Distribution of the respondents according to academic qualifications

Regarding the distribution of the respondents from the research sample according to the academic qualification categories, and based on Table (6), it was found that the majority of them were in the category of (Master's "MSc") with a contribution rate of (63.64%), followed by the category of (PhD") in second place with a percentage of (29.09%). As for the third and last place, it was held by the respondents who were among the Certified Public Accountants (CPA" with a contribution rate of (7.27%).

Table 6: Distribution of Respondents According to Certificate

Variable Categories	CPA	MSc	PhD	Total
Frequency	4	35	16	55
Percentage	7.27%	63.64%	29.09%	100%
Ranking According to Participation	3	1	2	

Source: Prepared by the researchers based on the results of the statistical analysis

c) Distribution of respondents according to years of experience:

Based on the table shown below, it is clear that the majority of those who participated in the research had years of experience within the category of five to ten years, with a participation rate of 56.36%. Then came the participation of the research sample members who had more than ten years of experience, with a participation rate of 29.09%. As for the third and last place, the participation was within the category of less than 5 years, with a percentage of 14.55%.

Table 7: Distribution of Respondents According to Years of Work Experience

Variable Categories	Less than (5) years	(5-10) years	More than (10) years	Total
Frequency	8	31	16	55
Percentage	14.55%	56.36%	29.09%	100%
Ranking According to Participation	3	1	2	

Source: Prepared by the researchers based on the results of the statistical analysis.

4.3.2. Description of the research axes (variables)

The research variables were described, including opinions and responses to the statements collected from the research sample. Statistical methods were used, including arithmetic means, standard deviations, percentages of agreement, and the coefficient of variation. The coefficient of variation was used to determine the degree of homogeneity of opinions in terms of convergence and divergence from each other. It is considered an important measure because its calculation relies on the values of arithmetic means and standard deviations. It should be noted here that the direction of opinions is determined in terms of levels of agreement based on the arithmetic mean (weighted) of the statements, according to the five-point Likert scale used in the current field study. The five scores of the scale were divided into five categories, as shown in the table below:

Table 8: Rating Scale According to the Five-Point Likert Scale

Response	Weighted Mean	Duration	Level
Strongly Disagree	From (1) to (1.79)	0.79	Low
Disagree	From (1.80) to (2.59)	0.79	
Neutral	From (2.60) to (3.39)	0.79	Medium
Agree	From (3.40) to (4.19)	0.79	High
Strongly Agree	From (4.20) to (5)	0.8	

Source: Prepared by the researchers.

Based on the table above, if the weighted arithmetic means fall within the range of 1 to 1.79, the opinions and responses are considered to be strongly disagreed (completely disagree). If they fall within the range of 1.80 to 2.59, the responses are considered to be in disagreement with the content of the relevant axis. In general, if the weighted or weighted arithmetic means for a paragraph or statement fall between 1 and 2.59, the degree of agreement with that statement is low (disagreement). If they fall within the range of 2.60 to 3.39, this means that the opinions are neutral or that the degree of agreement is moderate. Finally, if the weighted or weighted arithmetic means for the opinions fall within the range of 3.40 to 5 units, this means that the degree of agreement was high, meaning that the responses agreed on the meaning of the statement in question.

4.3.3. Description of the axis (blockchain stability contributes to enhancing transparency in public financial records)

From Table (9), which represents the descriptive statistics for the opinion scores according to the relevant axis statements, individually and collectively, at the level of the aggregated axis, it is clear that the opinion scores of the sample of respondents tend toward acceptance, based on the weighted arithmetic mean value of the aggregated statements, which amounted to (4.05) and an agreement rate of (80.95%). This indicates the availability of the indicators of the aforementioned axis from the perspective of the research sample members. As for the individual phrases, it was found that the degrees of agreement of opinions ranged between (4.15) as the highest value of the weighted arithmetic mean, which was represented by the phrase (Relying on blockchain reduces the chances of individual manipulation of financial data), where the degrees of opinions for the aforementioned phrase were tending towards agreement, as the percentage of agreement for the concerned phrase reached (82.91%), and between the lowest value of the arithmetic mean, which amounted to (3.93), with an agreement percentage of (78.55%) for the phrase (The immutability feature makes government financial records more reliable), where the degrees of opinions for the aforementioned phrase also tended towards agreement.

Table 9: Descriptive Analysis of the Dimension (The Immutability of Blockchain Contributes to Enhancing Transparency in Public Financial Records)

Statements	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Level of Acceptance	Direction	Ranking According to Importance
You believe that financial data recorded on the blockchain cannot be altered without a clear record of such modification.	4.05	0.56	13.77%	81.09%	agree	3
The immutability feature makes government financial records more reliable.	3.93	0.74	18.89%	78.55%	agree	5
Relying on blockchain reduces the chances of individual manipulation of financial data.	4.15	0.68	16.36%	82.91%	agree	1
The ability to track any modification in financial records enhances transparency.	4.02	0.83	20.60%	80.36%	agree	4
The use of blockchain makes officials more committed to financial laws and disclosure requirements.	4.09	0.73	17.77%	81.82%	agree	2
Aggregate Index	4.05	0.39	9.65%	80.95%	agree	

Source: Prepared by the researchers based on the results of the statistical analysis.

As for the coefficient of variation, it ranged from 13.77% for the statement that stated, "You believe that financial data recorded on the blockchain cannot be altered without a clear record of such modification," where the degrees of opinions were more homogeneous, convergent, and less divergent. As for the statement that stated, "The ability to track any modification in financial records enhances transparency," its coefficient value was 20.60%. This indicates that the degrees of opinions were more divergent and divergent from one another. In other words, the respondents were more dissimilar when it came to the aforementioned statement, meaning that their degrees of opinions were scattered and somewhat unreliable.

4.3.4. Description of the axis (instant access to financial data via Web3 platforms enhances citizens' confidence in budget disclosures)

According to Table (10), which represents the descriptive statistics for the opinion scores according to the relevant axis statements, individually and collectively, regarding the aggregated axis, it is clear that the opinion scores of the sample of respondents tend toward acceptance, based on the weighted arithmetic mean value for the aggregated statements, which amounted to (4.17) and an agreement rate of (83.35%). This indicates the availability of the indicators of the aforementioned axis from the perspective of the research sample members. As for the individual phrases, it was found that the degrees of agreement of opinions ranged between (4.33) as the highest value of the weighted arithmetic mean, which was represented by the phrase (Providing financial data in real time increases citizens' trust in the government), where the degrees of opinions for the aforementioned phrase were strongly inclined towards agreement, as the percentage of agreement for the concerned phrase reached (86.55%), and between the lowest value of the arithmetic mean, which amounted to (4.05),

with an agreement percentage of (81.09%) for the phrase (Immediate access to data supports better financial decision-making by oversight bodies), where the degrees of opinions for the aforementioned phrase also tended towards agreement.

Table 10: Descriptive Analysis of the Dimension (Instant Access to Financial Data Through Web3 Platforms Enhances Citizens' Trust in Budget Disclosures)

Statements	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Level of Acceptance	Direction	Ranking According to Importance
Providing financial data in real time increases citizens' trust in the government.	4.33	0.55	12.62%	86.55%	Strongly agree	1
Instant access to financial records allows for precise monitoring of budget spending.	4.31	0.47	10.82%	86.18%	Strongly agree	2
Financial data available instantly makes it easier for analysts and citizens to assess financial performance.	4.07	0.72	17.59%	81.45%	agree	4
The availability of real-time financial information reduces doubts about financial manipulation.	4.07	0.69	16.94%	81.45%	agree	3
Immediate access to data supports better financial decision-making by oversight bodies.	4.05	0.73	18.02%	81.09%	agree	5
Aggregate Index	4.17	0.42	10.15%	83.35%	agree	

Source: Prepared by the researchers based on the results of the statistical analysis.

As for the coefficient of variation, it was found to range between (10.82%) for the statement that stated, "Instant access to financial records allows for precise monitoring of budget spending," where the degrees of opinions were more homogeneous, convergent, and less divergent. As for the statement that stated, "Immediate access to data supports better financial decision-making by oversight bodies," its coefficient value was 18.02%. This indicates that the degrees of opinions were more different and divergent from one another. In other words, the respondents differed more regarding the aforementioned statement, meaning that the degrees of their opinions were scattered and somewhat unreliable.

4.3.5. Description of the axis (decentralized record keeping reduces the possibility of unilateral manipulation of financial data)

From Table (11), which represents the descriptive statistics for the opinion scores according to the relevant axis statements, individually and collectively, at the level of the aggregated axis, it is clear that the opinion scores of the sample of respondents tend toward acceptance, based on the weighted arithmetic mean value of the aggregated statements, which reached (4.05) and an agreement rate of (81.09%). This indicates the availability of the indicators of the aforementioned axis from the perspective of the research sample members. As for the individual phrases, it was found that the degrees of agreement of opinions ranged between (4.19) as the highest value of the weighted arithmetic mean, which was represented by the phrase (Adopting decentralized storage makes auditing processes more effective), where the degrees of opinions for the aforementioned phrase were tending towards agreement, as the percentage of agreement for the concerned phrase reached (83.82%), and between the lowest value of the arithmetic mean, which amounted to (3.96), with an agreement percentage of (79.27%) for the phrase (Storing financial data in a decentralized manner reduces the risks of manipulation by a single party), where the degrees of opinions for the aforementioned phrase also tended towards agreement.

Table 11: Descriptive Analysis of the Dimension (Decentralized Record-Keeping Limits the Possibility of Unilateral Manipulation of Financial Data)

Statements	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Level of Acceptance	Direction	Ranking According to Importance
Storing financial data in a decentralized manner reduces the risks of manipulation by a single party.	3.96	0.79	20.00%	79.27%	agree	5
Decentralized systems enhance transparency compared to traditional centralized systems.	3.98	0.87	21.88%	79.64%	agree	4
Sharing financial data among multiple parties reduces the likelihood of forgery.	4.09	0.65	15.79%	81.82%	agree	3
Adopting decentralized storage makes auditing processes more effective.	4.19	0.62	14.72%	83.82%	agree	1
Managing decentralized records supports strengthening government accountability in financial spending.	4.15	0.59	14.25%	82.91%	agree	2
Aggregate Index	4.05	0.42	10.46%	81.09%	agree	

Source: Prepared by the researchers based on the results of the statistical analysis.

As for the coefficient of variation, it was found to range between (14.25%) for the statement that stated (Managing decentralized records supports strengthening government accountability in financial spending), where the degrees of opinions were more homogeneous, convergent, and less divergent. As for the statement that stated (Decentralized systems enhance transparency compared to traditional centralized systems), its coefficient value was (21.88%). This indicates that the degrees of opinions were more different and divergent from one another. In other words, the respondents differed more regarding the aforementioned statement, meaning that the degrees of their opinions were scattered and somewhat unreliable.

4.3.6. Description of the axis (the use of smart contracts contributes to improving the accuracy and fairness of government spending)

According to Table (12), which represents the descriptive statistics for the degree of opinions according to the relevant axis statements, individually and collectively, at the level of the aggregated axis, it is evident that the degrees of opinions of the sample of respondents tend toward acceptance, based on the weighted arithmetic mean value of the aggregated statements, which amounted to (4.17) and an agreement rate of (83.35%). This indicates the availability of the indicators of the aforementioned axis from the perspective of the research sample members. As for the individual phrases, it was found that the degrees of agreement of opinions ranged between (4.20) as the highest value of the weighted arithmetic mean, which was represented by the phrase (Using smart contracts reduces human errors in budget management),

where the degrees of opinions for the aforementioned phrase were strongly inclined towards agreement, as the percentage of agreement for the concerned phrase reached (84.00%), and between the lowest value of the arithmetic mean, which amounted to (4.13), with an agreement percentage of (82.55%) for the phrase (Executing financial operations through smart contracts increases the transparency of financial reports), where the degrees of opinions for the aforementioned phrase also tended towards agreement.

Table 12: Descriptive Analysis of the Dimension (The Use of Smart Contracts Contributes to Improving the Accuracy and Fairness of Government Spending)

Statements	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Level of Acceptance	Direction	Ranking According to Importance
Smart contracts ensure that government spending is carried out according to predefined standards.	4.15	0.65	15.69%	82.91%	agree	4
Using smart contracts reduces human errors in budget management.	4.20	0.65	15.47%	84.00%	Strongly agree	1
Smart contracts promote fairness in the allocation of government financial resources.	4.18	0.55	13.09%	83.64%	agree	2
Executing financial operations through smart contracts increases the transparency of financial reports.	4.13	0.72	17.48%	82.55%	agree	5
Relying on smart contracts facilitates monitoring compliance with financial policies without direct intervention.	4.18	0.67	16.00%	83.64%	agree	2
Aggregate Index	4.17	0.32	7.71%	83.35%	agree	

Source: Prepared by the researchers based on the results of the statistical analysis

As for the coefficient of variation, it was found to range between (13.09%) for the statement that stated (Smart contracts promote fairness in the allocation of government financial resources), where the degrees of opinions were more homogeneous and convergent, and less divergent. As for the statement that stated (Executing financial operations through smart contracts increases the transparency of financial reports), its coefficient value was (17.48%). This indicates that the degrees of opinions were more different and divergent from one another. In other words, the respondents differed more regarding the aforementioned statement, meaning that the degrees of their opinions were scattered and somewhat unreliable.

4.3.7. Description of the axis (web3 interoperability supports integration with existing public accounting platforms, enhancing comprehensive transparency)

According to Table (13), which represents the descriptive statistics for the degree of opinions, based on the statements of the relevant axis, individually and collectively, at the level of the aggregated axis, it is evident that the degrees of opinions of the sample of respondents tend toward acceptance, based on the weighted arithmetic mean value of the combined statements, which amounted to (4.12) and an agreement rate of (82.33%). This indicates the availability of the indicators of the aforementioned axis from the perspective of the individuals in the research sample. As for the individual phrases, it was found that the degrees of agreement of opinions ranged between (4.22) as the highest value of the weighted arithmetic mean, which was represented by the phrase (System integration reduces the possibility of data loss or duplication), where the degrees of opinions for the aforementioned phrase were strongly tending towards agreement, as the percentage of agreement for the concerned phrase reached (84.36%), and between the lowest value of the arithmetic mean, which amounted to (4.02), with an agreement percentage of (80.36%) for the phrase (Interoperability facilitates the exchange of information between different government entities securely and transparently), where the degrees of opinions for the aforementioned phrase also tended towards agreement.

Table 13: Descriptive Analysis of the Dimension (The Interoperability of Web3 Systems Supports Integration with Current Public Accounting Platforms, Thereby Enhancing Overall Transparency)

Statements	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Level of Acceptance	Direction	Ranking According to Importance
Integration between Web3 systems and government accounting platforms facilitates the monitoring of financial data.	4.05	0.93	22.97%	81.09%	agree	4
Interoperable systems allow for faster and more accurate review of financial records.	4.18	0.58	13.88%	83.64%	agree	2
Linking Web3 systems with existing platforms supports transparency in financial disclosure.	4.11	0.69	16.67%	82.18%	agree	3
System integration reduces the possibility of data loss or duplication.	4.22	0.69	16.25%	84.36%	Strongly agree	1
Interoperability facilitates the exchange of information between different government entities in a secure and transparent way.	4.02	0.83	20.60%	80.36%	agree	5
Aggregate Index	4.12	0.40	9.84%	82.33%	agree	

Source: Prepared by the researchers based on the results of the statistical analysis.

As for the coefficient of variation, it was found to range between (13.88%) for the statement that stated, "Interoperable systems allow for faster and more accurate review of financial records," where the degrees of opinions were more homogeneous, convergent, and less divergent. As for the statement that stated, "Integration between Web3 systems and government accounting platforms facilitates monitoring of financial data," its coefficient value was (22.97%). This indicates that the degrees of opinions were more different and divergent from one another. In other words, the respondents were more dissimilar regarding the aforementioned statement, meaning that their degrees of opinions were scattered and somewhat unreliable.

4.3.8. Ordinal importance of the study variables (axes)

The ordinal importance of the five axes can be determined through the arithmetic mean values and the percentage of agreement for each of the research axes, based on the results shown in Table 14. We find that the two axes, "(The use of smart contracts contributes to improving

the accuracy and fairness of government spending)" and "Instant access to financial data through Web3 platforms enhances citizens' confidence in budget disclosures," ranked first in importance at good levels, with an arithmetic mean of (4.167) and an agreement percentage of (83.35%) for each of the two axes mentioned. The axis "The interoperability of Web3 systems supports integration with current public accounting platforms, thereby enhancing overall transparency" ranked second in importance, also at good levels, with an arithmetic mean of (4.116) and an agreement percentage of (82.33%). As for the axis "Decentralized record-keeping limits the possibility of unilateral manipulation of financial data," it ranked third. Importance based on the arithmetic mean and agreement percentage values of (4.055) and (81.09%), respectively. Finally, for the axis (The immutability of blockchain contributes to enhancing transparency in public financial records), it was found that the relative importance of the aforementioned axis amounted to 80.95%, based on the arithmetic mean value of 4.047, which indicates that the opinions indicate agreement, according to the opinions of the research sample.

Table 14: Description of the Study Dimensions

Dimensions	Arithmetic Mean	Standard Deviation	Coefficient of Variation	Level of Acceptance	Direction	Ranking According to Importance
The immutability of blockchain contributes to enhancing transparency in public financial records	4.047	0.39	9.65%	80.95%	agree	4
Instant access to financial data through Web3 platforms enhances citizens' trust in budget disclosures	4.167	0.42	10.15%	83.35%	agree	1
Decentralized record-keeping limits the possibility of unilateral manipulation of financial data	4.055	0.42	10.46%	81.09%	agree	3
The use of smart contracts contributes to improving the accuracy and fairness of government spending	4.167	0.32	7.71%	83.35%	agree	1
The interoperability of Web3 systems supports integration with current public accounting platforms, thereby enhancing overall transparency	4.116	0.40	9.84%	82.33%	agree	2

Source: Prepared by the researchers based on the results of the statistical analysis.

As for determining the degree of homogeneity of opinions, it was found that the values of the coefficient of variation were limited between (7.71%) as the lowest value for the axis (The use of smart contracts contributes to improving the accuracy and fairness of government spending), meaning that opinions were more homogeneous and convergent, and less divergent on the aforementioned axis, and the highest value of (10.46%) for the axis (Decentralized record-keeping limits the possibility of unilateral manipulation of financial data), where the degree of opinions on the relevant axis was less homogeneous and more divergent, meaning that the opinions of the respondents were somewhat scattered and divergent.

4.3.9. Interpretation of dimension rankings

The results show smart contracts and real-time access (both mean = 4.167) ranked slightly higher than blockchain immutability (mean = 4.047). This pattern reflects stakeholder prioritization of user-facing applications over foundational infrastructure.

Smart contracts and real-time dashboards offer tangible, immediate benefits that stakeholders can directly observe. Smart contracts automate budget controls and prevent unauthorized spending through programmed enforcement. Real-time access eliminates reporting delays and enables continuous monitoring. These capabilities address the operational challenges identified in Section 1.1: poor transparency, delayed reporting, and inadequate disclosure in ways that are immediately visible and actionable.

Blockchain immutability, while essential, operates at the infrastructure level. Its primary function is ensuring that recorded data cannot be altered, which provides long-term assurance but offers less immediate operational impact. The value of immutability becomes apparent when manipulation is attempted and prevented, making its benefits somewhat abstract compared to the direct functionality of smart contracts and real-time monitoring.

This ranking does not indicate skepticism about blockchain technology. All dimensions received strong endorsement (all means above 4.0), with relatively modest differences between them. Rather, the pattern reveals implementation priorities, suggesting that phased adoption should emphasize smart contracts and real-time reporting as entry points, with blockchain serving as the supporting infrastructure that ensures long-term data reliability.

"Overall, these findings reinforce the main hypothesis that Web3 technologies can significantly enhance transparency in government budget accounting through practical and immediately applicable tools such as smart contracts and real-time monitoring."

4.4. Testing the main research hypothesis

The main hypothesis is divided into two hypotheses: the null hypothesis, which states: "There is no statistically significant relationship between the use of Web3 technologies and the improvement of transparency in government budget accounting," and the alternative hypothesis, which states: "There is a statistically significant relationship between the use of Web3 technologies and the improvement of transparency in government budget accounting." To test the two hypotheses, the overall index, which represents the five axes combined, was tested. Based on the table below, it was found that the null hypothesis was rejected and the alternative hypothesis was accepted. This was based on the value of the t-statistic, which corresponds to the average of the five axes combined, which amounted to (31.772). This, in turn, was greater than the table value of the test, which amounted to (2.0045) at the statistical significance level of (0.05) and degrees of freedom of (54). Also, the statistical significance level of the test, which amounted to (0.000), was lower than the significance level assumed by the current study, which amounted to (0.05). This means that the degrees of opinions and answers tend towards Approval: Thus, we can accept the alternative hypothesis, which states: (There is a statistically significant relationship between the use of Web3 technologies and the improvement of transparency in government budget accounting), based on the positive sign of the test statistic value, as shown in the table below:

Table 15: Results of the T-Test Related to the Main Hypothesis

Dimensions	Arithmetic Mean	Standard Deviation	Test Value	Difference Between the Dimension Mean and the Hypothetical Mean (3)	Significance Level	Result
W1, W2, W3, W4, W5	4.111	0.259	31.772	1.111	0.000	Acceptance of the Hypothesis

Source: Prepared by the researchers based on the results of the statistical analysis.

4.4.1. The first sub-hypothesis

To test the validity of the researchers' claim regarding the first sub-hypothesis, which states that "There is no statistically significant relationship between the immutability feature of blockchain and transparency in public financial records," and based on the table below, it was found that the aforementioned claim, which was formulated in the form of the aforementioned hypothesis, is false. This is based on the value of the t-statistic corresponding to the average of the first axis. The first axis was tested collectively, "The immutability of blockchain contributes to enhancing transparency in public financial records," because the axis in question measures the researchers' claim, which amounted to (19.886), which in turn was greater than the table value of the test, which amounted to (2.0045) at the statistical significance level (0.05) and degrees of freedom (54), or through the statistical significance level of the test, which amounted to (0.000), as it was less than the significance level assumed by the current study, which amounted to (0.05). Thus, we can reject the null hypothesis, which states that the degrees of opinions are neutral. We accept the alternative hypothesis, that is, the degrees of opinions and answers tend towards approval, based on the positive sign of the test statistic value, and thus the first sub-hypothesis is not accepted from the point of view of the respondents.

Table 16: Results of the t-Test Related to the First Sub-Hypothesis

Dimensions	Arithmetic Mean	Standard Deviation	Test Value	Difference Between the Dimension Mean and the Hypothetical Mean (3)	Significance Level	Result
The immutability of blockchain contributes to enhancing transparency in public financial records	4.047	0.391	19.886	1.047	0.000	Acceptance of the Hypothesis

Source: Prepared by the researchers based on the results of the statistical analysis.

4.4.2. Second sub-hypothesis

To test the validity of the researchers' claim regarding the second sub-hypothesis, which states that "There is no statistically significant relationship between real-time access to financial data through Web3 platforms and citizen trust in budget disclosures," and based on the table below, it was found that the aforementioned claim, which was formulated in the form of the aforementioned hypothesis, is not valid. This is based on the value of the t-statistic corresponding to the average of the second axis. "The second axis was tested collectively, "Instant access to financial data through Web3 platforms enhances citizens' trust in budget disclosures," because the axis in question measures the researchers' claim, which amounted to (20.466), which in turn was greater than the table value of the test, which amounted to (2.0045) at the statistical significance level (0.05) and degrees of freedom (54), or through the statistical significance level of the test, which amounted to (0.000), as it was less than the significance level assumed by the current study, which amounted to (0.05). Therefore, we can reject the null hypothesis. This stipulates the neutrality of the degrees of opinions, and we accept the alternative hypothesis, meaning that the degrees of opinions and answers tend towards approval, based on the positive sign of the value of the test statistic, and thus the second sub-hypothesis is not accepted from the point of view of the respondents.

Table 17: Results of the t-Test Related to the Second Sub-Hypothesis

Dimensions	Arithmetic Mean	Standard Deviation	Test Value	Difference Between the Dimension Mean and the Hypothetical Mean (3)	Significance Level	Result
Instant access to financial data through Web3 platforms enhances citizens' trust in budget disclosures	4.167	0.423	20.466	1.167	0.000	Acceptance of the Hypothesis

Source: Prepared by the researchers based on the results of the statistical analysis.

4.4.3. The third sub-hypothesis

To test the validity of the researchers' claim regarding the third sub-hypothesis, which states that "There is no statistically significant relationship between decentralized recordkeeping and the risk of unilateral manipulation of financial data," and based on the table below, it was found that the aforementioned claim, which was formulated in the form of the aforementioned hypothesis, is not valid based on the value of the t-statistic corresponding to the average of the third axis. The third axis was tested collectively, "Decentralized record-keeping limits the possibility of unilateral manipulation of financial data," because the axis in question measures the researchers' claim, which amounted to (18.437), which in turn was greater than the table value of the test, which amounted to (2.0045) at the statistical significance level (0.05) and degrees of freedom (54), or through the statistical significance level of the test, which amounted to (0.000), as it was less than the significance level assumed by the current study, which amounted to (0.05). Thus, we can reject the null hypothesis, which states: The degrees of opinions are neutral, and we accept the alternative hypothesis, meaning that the degrees of opinions and answers tend towards approval, based on the positive sign of the test statistic value, and thus the third sub-hypothesis is not accepted from the point of view of the respondents.

Table 18: Results of the T-Test Related to the Third Sub-Hypothesis

Dimensions	Arithmetic Mean	Standard Deviation	Test Value	Difference Between the Dimension Mean and the Hypothetical Mean (3)	Significance Level	Result
Decentralized record-keeping limits the possibility of unilateral manipulation of financial data	4.055	0.424	18.437	1.055	0.000	Acceptance of the Hypothesis

Source: Prepared by the researchers based on the results of the statistical analysis.

4.4.4. Fourth sub-hypothesis

To test the validity of the researchers' claim regarding the fourth sub-hypothesis, which states that "There is no statistically significant relationship between the use of smart contracts and the accuracy and fairness of government spending," and based on the table below, it was found that the aforementioned claim, which was formulated in the form of the aforementioned hypothesis, is not valid based on the

value of the t-statistic corresponding to the average of the fourth axis. "The fourth axis was tested collectively" The use of smart contracts contributes to improving the accuracy and fairness of government spending ", because the axis in question measures the researchers' claim, which amounted to (26.927), which in turn was greater than the table value of the test, which amounted to (2.0045) at the statistical significance level (0.05) and degrees of freedom (54), or through the statistical significance level of the test, which amounted to (0.000), as it was less than the significance level assumed by the current study, which amounted to (0.05). Thus, we can reject the null hypothesis, which states: The degrees of opinions are neutral, and we accept the alternative hypothesis, meaning that the degrees of opinions and answers tend towards approval, based on the positive sign of the test statistic value, and thus the fourth sub-hypothesis is not accepted from the point of view of the respondents.

Table 19: Results of the T-Test Related to the Fourth Sub-Hypothesis

Dimensions	Arithmetic Mean	Standard Deviation	Test Value	Difference Between the Dimension Mean and the Hypothetical Mean (3)	Significance Level	Result
The use of smart contracts contributes to improving the accuracy and fairness of government spending	4.167	0.321	26.927	1.167	0.000	Acceptance of the Hypothesis

Source: Prepared by the researchers based on the results of the statistical analysis.

4.4.5. Fifth sub-hypothesis

To test the validity of the researchers' claim regarding the fifth sub-hypothesis, which states that "There is no statistically significant relationship between the interoperability of Web3 systems and the enhancement of transparency in government accounting systems," and based on the table below, it was found that the aforementioned claim, which was formulated in the form of the aforementioned hypothesis, is not valid based on the value of the t-statistic corresponding to the average of the fifth axis. "The fifth axis was tested collectively" The interoperability of Web3 systems supports integration with current public accounting platforms, thereby enhancing overall transparency ", because the axis in question measures the researchers' claim, which amounted to (20.445), which in turn was greater than the table value of the test, which amounted to (2.0045) at the statistical significance level (0.05) and degrees of freedom (54), or through the statistical significance level of the test, which amounted to (0.000), as it was less than the significance level assumed by the current study, which amounted to (0.05). Therefore, we can reject the hypothesis. The negative hypothesis, which states that the degrees of opinions are neutral, and we accept the alternative hypothesis, meaning that the degrees of opinions and answers tend towards approval, based on the positive sign of the value of the test statistic, and thus the fifth sub-hypothesis is not accepted from the point of view of the respondents.

Table 20: Results of the T-Test Related to the Fifth Sub-Hypothesis Web3 Interoperability and Transparency Enhancement (N=55)

Dimensions	Arithmetic Mean	Standard Deviation	Test Value	Difference Between the Dimension Mean and the Hypothetical Mean (3)	Significance Level	Result
The interoperability of Web3 systems supports integration with current public accounting platforms, thereby enhancing overall transparency	4.116	0.405	20.445	1.116	0.000	Acceptance of the Hypothesis

Source: Prepared by the researchers based on the results of the statistical analysis.

5. Conclusions

a) The study confirmed that Web3 technologies as a whole are positively correlated with enhancing governmental financial transparency. From an accounting perspective, this discovery validates the Full Disclosure Principle, which requires governments to provide all that is financially pertinent completely and transparently to stakeholders, increasing accountability and reducing information asymmetry.
b) Blockchain immutability reduced the possibility of manipulation of government finance information. This is consistent with the accounting principle Reliability of Accounting Records, as immutability ensures financial transactions, once recorded, cannot be altered subsequently, thereby increasing the reliability and auditability of government financial reports.
c) Real-time access to financial data was discovered to boost citizens' trust in government releases. This result is consistent with the accounting principle of Timeliness since rendering concurrent access to budget data makes government reporting near Real-Time Financial Reporting, improves monitoring, decision-making, and public trust.
d) Decentralization of accounting minimizes the risks of one-entity dominance of governmental fiscal information. From an accounting perspective, the outcome upholds the theory of Internal Control, since decentralization prevents control from being in the possession of one party and also enhances effectiveness in internal as well as external auditing.
e) Smart contracts were demonstrated to increase the accuracy and equity of government spending. On accounting premises, smart contracts operate as Automated Spending Controls, meaning that spending has effect only upon the occurrence of pre-agreed legal and financial conditions, thereby reducing the risk of human errors, protecting against mis-payments, and ensuring easier budget compliance.
f) Web3 technologies interoperability facilitates compatibility with existing government accounting systems. This finding reflects the concept of Comprehensive Accounting Control in the sense that interoperability facilitates reconciliation between budgeting systems, procurement, payroll, and general ledger systems, and thus provides comparability and consistency of government financial reporting.
g) The incremental adoption of Web3 technologies enables governments to build a more transparent and accountable financial environment. This result is consistent with the idea of Financial Accountability as the adoption of Web3 fosters improved financial reporting, reduces information gaps in the public sector, and facilitates higher societal trust in government institutions.

6. Recommendations

a) Incremental Adoption of Web3 Technologies: Governments need to introduce Web3 technologies gradually to enhance financial accountability and transparency. Introducing new systems gradually allows stakeholders to adapt to new systems while adhering to prevailing accounting standards.
b) Utilization of Blockchain-Based Accounting: It is recommended that government financial institutions adopt blockchain technology in budget and accounting systems to have irreversible accounts. This action will reduce the risk of data manipulation and increase financial report reliability.
c) Design of Real-Time Financial Reporting Platforms: Public sector entities will need to design real-time financial dashboards to provide constant access to citizens and overseers to budget data. The platforms will align with the accounting principle of timeliness and will contribute significantly towards raising public confidence in government financial disclosure.
d) Fostering Decentralized Recordkeeping for Internal Control: Governments are encouraged to implement decentralized data management systems to share power and improve internal control. This will minimize risks encountered as a result of one-sided decision-making and improve the quality of internal and external audits.
e) Smart Contracts Integration into Public Spending: Public financial management systems should incorporate smart contracts for budgetary controls automation. This ensures that expenditures are made only when certain legal and financial requirements are fulfilled, thereby enhancing accuracy, fairness, and compliance in public spending.
f) Enhancing Interoperability with Current Accounting Systems: Enhancing interoperability among Web3 solutions and current government accounting, payroll, and procurement infrastructure is imperative. Integrating these will facilitate effortless reconciliation, improve data congruence, and ensure reporting comparability.
g) Enhancing Institutional and Legal Frameworks: To maximize the benefits of Web3, policymakers have to create a supportive institutional and legal framework that governs data openness, accountability, and digital financial reporting. This will set a strong foundation for sustainable adoption and long-term change in the public sector.

7. Future Research and Regional Application

Although this research was conducted within the context of the Kurdistan Region–Iraq, there is strong potential to extend its scope in future studies. Many developing countries—especially in the Middle East, North Africa, and other emerging markets—face comparable challenges related to public financial transparency, digital government readiness, and regulatory transitions.
Therefore, applying the proposed Web3 transparency framework in these environments would be valuable. Such efforts would not only help verify and refine the model but also contribute to a broader understanding of how similar economies might benefit from Web3 technologies to strengthen budget transparency and public accountability. Future research may explore these regional contexts to build on the insights of this study and expand its practical and academic contributions.

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