Sovereign Governance: Distributed Certification of Corporate Transactional State

Abstract—This paper presents an on-chain methodology for certifying, registering, and querying institutional transactional status using blockchain technology. It proposes a framework for decentralized governance, leveraging consensus mechanisms and smart contracts to automate business rules, aiming to reduce transaction costs associated with contractual measurement reports and enhance transactional integrity in corporate governance.

Index Terms—Blockchain, Decentralized Governance, Consensus Mechanism, Smart Contracts, Corporate Governance

I. Introduction

The advent of blockchain technology heralded a transformative paradigm for the global financial system. As a decentralized and tamper-proof data repository, the distributed communication protocol offers a solution for executing a high volume of transactions in environments where trust is essential and supplanted by the incentive structure of the distributed design.

Blockchain technology, originating from Nakamoto's seminal work [1], is fundamentally a form of *Distributed Ledger Technology* (DLT) that employs a unique data structure to ensure decentralized, transparent, and secure data storage across various network nodes. Initially, the architecture of blockchain technology was harnessed to support Bitcoin, the pioneering cryptocurrency. However, since its inception, blockchain applications have extended beyond the cryptocurrency domain, showcasing immense utility in economic sectors [2].

A salient attribute of blockchains is their append-only nature, suggesting that while new blocks can be appended to the chain's end, altering the content of an existing block necessitates modifying all subsequent blocks [3]. This distinctive feature bolsters the security and integrity of data embedded in the blockchain.

At the heart of blockchain technology lies the concept of decentralized consensus, an attribute eliminating the need for a controlling entity or third-party trust to validate transactions. This consensus mechanism ensures unanimous agreement on the ledger's state among all network participants. As a result, blockchain's decentralized nature curtails potential fraud, substantially cutting transaction costs [2] and contributing to the institutional ESG score.

Nevertheless, significant challenges in utilizing blockchain for financial operations include establishing the credibility and truthfulness of financial data before logging into the protocol and managing access control to sensitive information. These challenges are especially pronounced in corporate financial data management, where disclosure constraints and data validation emerge as legal requirements and competitive advantages.

The focus of this paper is proposing a methodology to synchronize the transactional status of contracts between two companies through a private consensus mechanism applied to register measurement reports on a public blockchain. Within the framework we suggest for recording corporate financial and inventory data, blockchain technology offers an ideal solution for creating a secure, transparent, and unchangeable transaction record. The dialectical process involves multiple parties with differing interests discussing interpretation contrasts before a network record is made, and coupled with blockchain's decentralization, it removes the need for a central authority. Moreover, the append-only nature of blockchain ensures that once financial or inventory data is recorded, it remains unaltered. Additionally, the inherent consensus mechanism of blockchain provides a robust validation method, promoting trust between institutions and encouraging more transactions.

Considering a contractual relation mutually dependent on the data of the transactional state, such as a Service Level Agreement for example, the hypothesis studied is: Will the cost of synchronization of the transactional state between multiple organizations be compensated by the reduction on the total cost of operation *(TCO)*?

As a scientific proposition, we introduce a methodology termed *Sovereign Governance* to foster contractual truthfulness, register, and abstract the physical-financial transactional data of both managerial reports and institutional inventories using blockchain technology. This structure deploys a multi-stakeholder consensus mechanism, obviating the need for a certifying authority or external audit vouching for its credibility.

A. Motivation

In 2019, the steel industry in Latin America faced one of its gravest challenges – a steel ladle leakage, dispensing tons of molten steel that melted the metallic structure of the factory. After hundreds of millions in accounted losses, the CEOs of the steel industry and the raw material supplier that supported the equipment in question gathered in a regime consequence meeting to stipulate the responsibilities for the loss. A peculiarity in the case motivated this research: the document which was a setup requirement for the equipment to work on was not found after the incident. That was the pinnacle of the problem, and it raised only two possible scenarios. Either the document was never produced and there was a critical process failure, or it was kidnapped after the fact. This real anecdotal case

illustrates the importance of registering the transactional state between companies in as immutable communication protocol. Otherwise, institutions may fall under the false impression of satisfactory information security, but when crises hit, they discover that centralized governance - which means keeping records on traditional databases - do not suffice for real world demands.

Considering the hard teachings of that episode, the development of a sovereign governance framework began to be developed in 2019, rooted in real world institutional necessities regarding the knowledge management of the contractual transactional state between companies.

In this study, our goal is to reduce transaction costs arising from uncertainties during negotiations and the recording of ongoing operations among involved parties. The objective is to stimulate a higher volume of economic transactions, enhancing trust among institutions by implementing a resilient and transparent mechanism to validate transactional states.

The formulation and execution of the proposed solution could mark the onset of a new era in decentralized financial transactions, streamlining corporate finance and inventory management. It represents an innovative method for validating data and preserving privacy in blockchain transactions. These advancements might initiate a significant change in how institutions interact and conduct transactions, unlocking the unexplored capabilities of blockchain technology in corporate governance.

II. THE PROBLEM WITH CENTRALIZED GOVERNANCE

Corporate governance is perceived as a complex system according to the classical definition of complexity theory. [4] One of the most critical subsystems of governance is the information security methodology, a semantic ensemble that encompasses all the issues detailed henceforth.

The first challenge addresses the centralization of truth in institutional transactional records. In present-day accounting, operational and contractual records, the institution itself remains the sole source of transactional information. The absence of counter-parties with divergent interests to validate transactional state - where audits fail to meet this requirement due to a well-known dilemma termed the "agency problem" - paves the way for potential frauds, friction and inefficiencies. [5].

Another significant concern lies in the lack of version control, given the absolute mutability of accounting records over time. There's a void regarding cryptographic commitment [6], which would immutably log the entire history of record modifications, inclusive of their final version. Logging such a history prohibits the deployment of *quantitative easing* techniques in account manipulation.

One of the most prominent contractual arbitration center in the world is the Financial Industry Regulatory Authority that is receiving a crescendo of cases from 2019 to 2023. This tendency of demand for arbitrage illustrates the problematic towards centralized governed contracts.

Considering SLA contracts between two institutions, centralized governance practices, regarding institutional knowl-
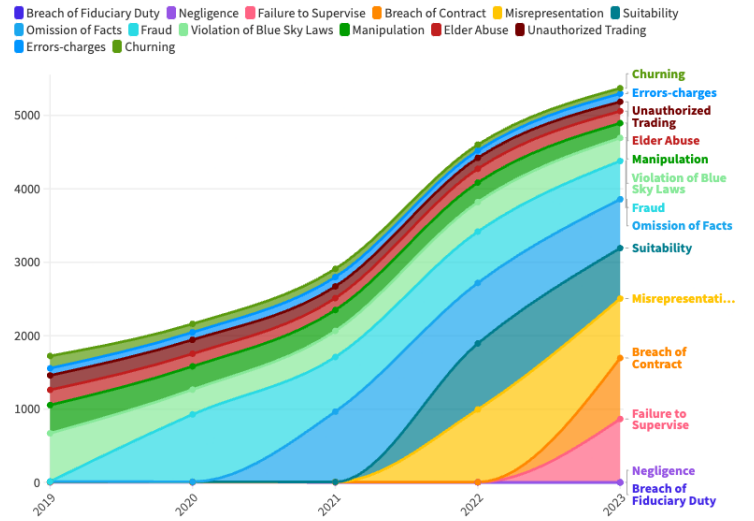

Fig. 1. Most frequent controversy types in contractual arbitration from 2019 to 2023 - Finra

edge management served organizations until the present moment in only two possible modalities. In the first one, considered primitive, one company, either supplier or costumer, registers the operational measurements and provides a unilateral source of trust in which the other organization must passively accept. In the second approach, both institutions collected separated records of transactional data, stored on their respective ERP systems as a control mechanism that needs to be synchronized at each SLA billing cycle. This temporal and methodological hiatus in synchronizations leads to what can be formulated in a general sense as contractual disputes. There are several contractual controversy types, as all of them present financial impacts that result in a perceived underbilling or overbilling - these ambivalent omnipresent phenomena are not considered categories by arbitration research centers, as seen on Figure 1.

III. METHODS

The studied scientific hypothesis is: if a mathematically verifiable consensus mechanism is implemented to manage the entire contractual relationship between two parties or more, regarding the financial and physical change of state during the contractual period, is it capable of producing desirable benefits focused on transactional efficiency, per se, capable of reducing transactional costs?

A. Overview

This study employed a mixed-method approach, a technical implementation case study with a statistical analysis of results to evaluate the implementation and efficacy of a blockchain-based Sovereign Governance (SG) methodology within two industrial sectors: steel and oil. The primary objective was to determine if the SG methodology could effectively reduce contractual disputes, overbilling, and enhance overall transactional integrity.

B. Study Period

This case study was conducted over a significant duration from 2019 to 2023. The timeframe allowed for a detailed exploration and assessment of the long-term impacts of implementing a blockchain-based Sovereign Governance (SG) methodology within complex industrial sectors.

C. Participants and Settings

The study primarily focused on two large industrial corporations, anonymized as Steel-Supplies S.A and Oil Drilling S.A. These entities were chosen due to their significant market presence and the complex nature of their contractual processes.

For Steel-Supplies S.A, the observation period spanned from 2021 to 2023, during which the company engaged with five distinct industrial counterparties. Throughout this period, 26 contractual measurement reports were meticulously analyzed, involving 78 blockchain transactions, each authenticated with blockchain signatures.

As of Oil Drilling S.A, the study covered the years 2022 and 2023. This company's interactions were limited to one primary industrial counterparty. The data collected included eight detailed contractual measurement reports, encompassing 32 blockchain transactions and signatures.

D. Methodological Approach

The methodology was structured into three distinct phases, each pivotal to the success of the SG implementation:

1) Phase 1: Preliminary Assessment and Planning: The initial phase involved an in-depth survey and analysis of the existing macro service measurement processes within the participating companies. A cross-functional working group was established, comprising members from diverse departments such as finance, operations, legal, and IT. This phase also included a strategic selection and analysis of high-potential contracts for the pilot study, chosen based on their complexity, financial significance, and historical dispute records.

2) Phase 2: Blockchain Development and Integration: In this phase, the focus shifted to the technical development of the SG methodology. This involved the translation of complex business rules into programmable logic within smart contracts. These contracts were then subjected to a series of rigorous tests for functionality, security, and compliance before being deployed on the blockchain network. An integral part of this phase was the integration of the companies' existing IT systems with the blockchain infrastructure to ensure seamless data transmission and recording.

3) Phase 3: Implementation and Monitoring: The final phase saw the establishment of a blockchain environment tailored to the specific needs of the users. This environment was designed to be user-friendly, ensuring ease of interaction with the smart contracts for various stakeholders. Extensive training sessions were conducted to familiarize users with the new system. Throughout this period, continuous monitoring and data collection were carried out, focusing on various parameters such as the number of contractual measurement reports, blockchain transactions, and instances of disputes.

E. Data Collection and Analysis

Data collection captured two aspects of the contractual process, SLA financial smart-contract automated calculation based on signed consensus of operational truth and recorded contractual disputes. The smart-contracted automated SLA calculations were compared with the status quo calculations, and the disputes were compared with a compatible timeframe previous to the implementation of the SG methodology.

An Analysis of Variance (ANOVA) was conducted to assess the impact of the SG methodology on the percentage of contractual variation between the automated and status-quo values, in order to establish statistical significance to the reduction of overbilling in contracts.
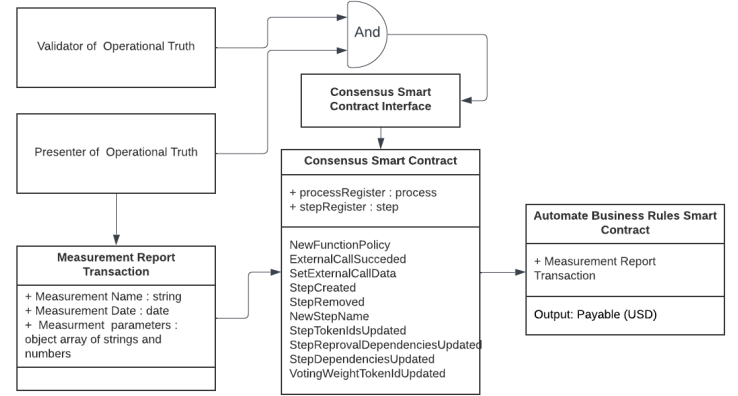

Fig. 2. Technical UML diagram illustrating the sovereign governance methodology

IV. RESULTS

The application of the Sovereign Governance (SG) methodology, which is composed by a corporate consensus mechanism regarding the operational state followed by a smart contract as illustrated by Figure 2, within Steel-Supplies S.A and Oil Drilling S.A, spanning from 2019 to 2023, demonstrated significant empirical outcomes in TOC reduction. In Steel-Supplies S.A, across a two-year implementation phase (2021-2023), with five industrial counterparties, there were 26 contractual measurement reports in which the last three were fully automated. A notable reduction of 10% in contractual disputes was observed, alongside a measurable decrease in the measurement report calculation time, which impacted the receivables anticipation process by an average of 5 days. Most importantly, contract miscalculations, encompassing overbilling, were reduced by 2.42%.

In the context of Oil Drilling S.A, during the shorter span of 2022 to 2023 and engaging with a single counterparty, 8 contractual measurement reports were analyzed. The company experienced a 20% reduction in contractual disputes, an impressive average reduction of 14 days in the measurement report calculation time, and a 1.8% decrease in contract miscalculations leading to direct savings.

By comparison of the contractual dispute rates from previous periods, an enhancement on contractual fluidity attributed to the synchronization of the operational state via a consensus mechanism with decentralized records can be perceived on both subjects, because dispute data is scarce and sporadic no statistical analysis was conducted in order to prevent bias.
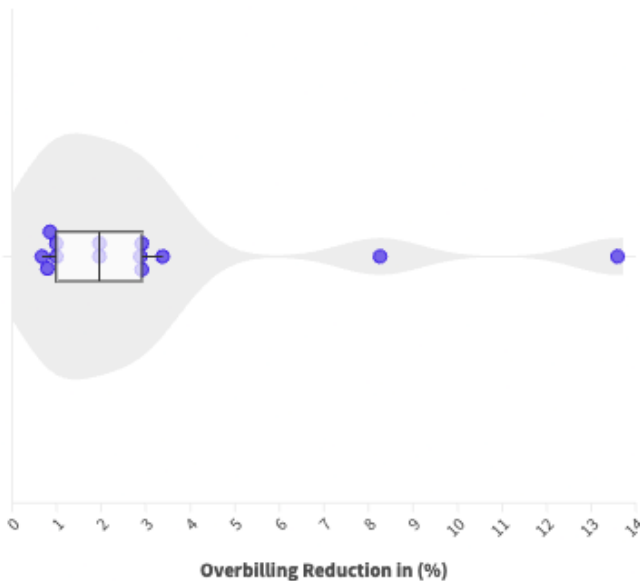

Fig. 3. Industrial Measurement Reports Automation from 2021 to 2023.

As it can be observed on Figure 3 all measurement reports automated presented some level of overbilling. Some of the speculative, but not extensive, causes of overbilling were, non application of contractual clauses, rounding, human error, and traditionalism on status-quo. Considering contract calculation data, the studied SLAs presented a fixed and recurrent measurement period of monthly cycles, what enabled a deeper quantitative analysis. From a statistical standpoint, the study employed an ANOVA analysis to scrutinize the overbilling reduction, revealing an F-ratio value of 9.98155 and a p-value of 0.004237. The statistical significance of these results, at $p < 0.01$, robustly rejects the null hypothesis, establishing that the algorithmic implementation of business rules automation via smart contracts led to a measurable and substantial decrease in overbilling incidents.

V. DISCUSSION

The integration of blockchain technology, particularly the SG methodology, into the contractual processes of these industrial giants demonstrated not only a reduction in contractual disputes but mainly a reduction in overbilling. A robust indicative of the visibility and conformity that blockchain and smart contracts introduce into traditional business processes.

From an economic standpoint, the reduction in receivables anticipation days signifies an improvement in cash flow management, a crucial aspect for any industrial operation. The digital methodology to standardize the management of operational reports and occurrences, and the automation provided by smart contracts, directly contribute to these efficiencies, mitigating the risk of human error and subjective interpretation of contractual terms.

The study highlights the robustness of blockchain as a secure and transparent medium for contractual agreements. The cryptographic nature of blockchain provides a level of security and immutability that traditional digital transactions cannot match. This security is paramount in industries where the stakes of contractual breaches or disputes are high.

VI. CONCLUSION

The study corroborates the critical significance of blockchain technology in streamlining contractual governance within industrial sectors in order to reduce total operating costs. The Sovereign Governance methodology implementation yielded quantifiable improvements in overbilling reduction (average = 2.11%), ameliorated dispute resolution, and increased operational efficiency. These results not only reduced transaction costs but pave the way for establishing a new governance standard where companies are capable of synchronizing transactional state in order to consensually automate business rules calculations to reduce transaction costs.

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