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Multilateral Offsetting: Economic Efficiency and Legal Constraints

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Abstract **Original Research Article**

The relevance of the study is stipulated by the need to increase liquidity and reduce the transaction burden in the small and medium-sized business sector of Kazakhstan, which operates under conditions of limited access to bank lending. In this context, multilateral netting is a promising tool for optimizing inter-corporate settlements, but its effective implementation is constrained by a lack of trust and coordination among participants. The introduction of blockchain technologies allows solving these problems through decentralized data management, transparency of transactions and automation of the terms of repayment of obligations.

The purpose of the study is to substantiate and build a conceptual model of multilateral offsetting using blockchain architecture for the needs of the private sector of Kazakhstan, as well as to assess the potential economic benefits and legal constraints associated with implementing of such a system.

Methodology. The study applies a comparative analysis of scientific sources, modeling of economic efficiency scenarios based on a conditional case with 8 enterprises, as well as a structural and functional approach to building a blockchain offset architecture taking into account regulatory requirements. The method of legal analysis is used to identify national and international barriers to the implementation of smart contracts.

Results. It has been established that the proposed model can reduce the need for cash payments by up to 42 % and reduce debt service costs by up to 35 % in a scalable environment. It has been found that the key legal barriers are the lack of a special status for smart contracts, uncertainty in the taxation of tokenized assets, and limited integration of blockchain technologies into national legislation.

Conclusions. It is proven that a decentralized offsetting system can increase the economic sustainability of enterprises and reduce the systemic risks of receivables. It is shown that effective implementation requires regulatory clarity and the creation of institutional conditions for testing innovative financial technologies.

Prospects for further research. It is advisable to empirically test the model in the context of pilot projects, as well as to compare legal regimes for multilateral netting and blockchain solutions across countries.

Keywords: smart contracts, digital liquidity, private settlements, blockchain infrastructure, financial decentralization.

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1. INTRODUCTION

1.1 Relevance and context of the study

In the current environment of high dynamics of financial and economic processes and limited liquidity, instruments that can reduce transaction costs and increase the solvency of enterprises are of particular relevance. One of these instruments is multilateral netting, a mechanism where several participants simultaneously settle their mutual obligations without the need for real cash transfers. This minimizes the financial burden, increases the turnover of funds, and avoids cash gaps, which is critical for private businesses, especially in an unstable economic environment.

For the private sector of Kazakhstan, which often faces limited access to credit, high levels of receivables and growing costs of servicing financial obligations, the introduction of multilateral netting is of practical value. In such conditions, the integration of blockchain technologies as a tool that ensures automation, transparency and trust between the participants of the multilateral netting deserves special attention. Smart contracts, distributed ledgers, and cryptographic data protection create the

basis for a reliable digital environment where all participants can securely offset in real time.

1.2. Challenges in implementing multilateral offsetting

The use of innovative solutions becomes even more justified in the context of Kazakhstan's digital transformation. Favorable regulatory initiatives, such as the development of a legal framework for digital assets, support for fintech projects within the framework of the Astana International Financial Center (AIFC) (AIFC, 2024a), and the implementation of new digital standards in 2023-2024 (QazInform, 2024), create the necessary conditions for the practical implementation of blockchain-based multilateral netting. In this context, the proposed initiative to form a system of multiple offsetting between non-state enterprises in Kazakhstan has not only theoretical but also high applied significance.

At the same time, despite its potential advantages, the implementation of multilateral netting mechanisms using blockchain technologies faces several challenges that hinder widespread adoption. These include coordination difficulties among participants with varying financial cycles and debt structures, a lack of trust in digital transactions, and legal constraints related to the recognition of the legal validity of smart contracts, as well as restrictions on data sharing and confidentiality.

Notably, the scientific literature contains limited research on the implementation of multilateral netting in developing countries, including Kazakhstan. Most existing publications focus on centralized financial systems or examples from developed economies. This creates both methodological and practical gaps, making it impossible to directly apply foreign experience to the Kazakh context without proper adaptation to local legal frameworks, business practices, and technological infrastructure.

Therefore, this paper aims to examine the economic feasibility and legal constraints associated with the implementation of multilateral offsetting using blockchain technologies in the non-state enterprise sector of Kazakhstan.

1.3. Objective and research questions

The purpose of the study is to develop a conceptual model of a blockchain-based multilateral offsetting system for private enterprises in Kazakhstan and to assess its economic efficiency and legal limitations.

The study aims to address the following questions:

1. How can blockchain technologies increase the cost-effectiveness of multilateral offsetting in the private sector of Kazakhstan?

2. What legal constraints complicate the implementation of such a system?

3. What regulatory mechanisms can help overcome these limitations?

1.4. Limitations of the study and practical relevance

The study is limited to analyzing the possibilities of implementing a blockchain-based multilateral offset system in the context of private enterprises in Kazakhstan, with a special focus on small and medium-sized enterprises (SMEs). The study's object does not include government agencies and public sector organizations. The primary focus is on blockchain as a key infrastructure technology that ensures automation, transparency and reliability of financial interactions between business entities.

From a scientific perspective, the paper contributes to the advancement of research in the field of distributed ledger technologies in the financial systems of developing countries, f laying the theoretical basis for further analysis of decentralized offsetting mechanisms. The proposed conceptual model expands the understanding of blockchain’s potential in the context of optimizing intercompany settlements.

From a practical point of view, the study is of practical importance for business entities, developers of digital infrastructure and economic regulators, as it offers an algorithm for building an effective system of multilateral netting. Such a model can help reduce transaction costs, increase the liquidity of enterprises, and reduce financial risks in the private sector.

It is expected that the study's results will have a positive impact on Kazakhstan's economy, particularly by supporting SMEs and aligning with the state's digitalization priorities, which are being implemented within the framework of national development strategies and programs.

2. LITERATURE REVIEW

Modern research on multilateral offsetting identifies four interrelated areas of investigation. The first area involves modeling the economic efficiency of multilateral mechanisms within financial and resource systems. Frank et al. (2021) examine the effectiveness of unilateral measures in agriculture to mitigate climate change, concluding that only multilateral commitments can produce a significant global impact at an acceptable cost. Byck and Heijmans (2020) propose a simulation-based approach for assessing the liquidity effects of implementing a resource preservation mechanism in the Canadian payment system, demonstrating that multilateral netting can reduce liquidity needs by more than 20 percent without compromising efficiency. Kasdan et al. (2021) investigate the evolution of climate adaptation financial funds and find that only a multilateral governance framework can ensure the equitable distribution of funding across countries. These studies highlight the considerable potential of multilateral offsetting in optimizing economic interactions; however, the challenge of scaling models in sectors characterized by high transaction density persists. Future research should focus on developing macro-level models to assess the impact of netting on liquidity, resilience, and resource allocation in the real sector.

The second area focuses on the technological foundations of decentralized credit, particularly the application of blockchain solutions. Cao et al. (2020) propose a private netting protocol on the blockchain that enables privacy-preserving balance verification, a critical factor for adoption in the business environment. Priem (2020) analyzes the benefits and risks associated with using distributed ledger technology (DLT) for securities clearing, emphasizing the potential of the technology to substantially reduce both costs and settlement times. Sapa (2025) introduces the concept of using digital tokens for inter-enterprise offsetting in Kazakhstan, with blockchain functioning as a tool for guaranteed settlements without the involvement of banking intermediaries. Abiodun et al. (2025) review the use of blockchain in emissions trading systems, highlighting the potential of netting as a mechanism for obligation accounting. These studies illustrate the technical maturity of blockchain solutions in supporting multi-party computation; however, additional research is required to ensure scalability, regulatory compliance, and interoperability across different DLT platforms.

The third area addresses the legal and regulatory constraints affecting the development of multilateral credit. Downes and Reed (2020) explore the use of distributed ledgers to enhance transparency in global energy supply chains, drawing attention to the risks associated with regulatory fragmentation. Lim and Pan (2021) propose the concept of a global social contract for blockchain-based digital trading platforms, positioning multilateral offsetting within the framework of equity and shared responsibility.

Thanasi-Boçe and Hoxha (2025), in a systematic review, emphasize that the implementation of blockchain solutions, particularly netting, requires regulatory reform to ensure alignment with sustainable development goals. Holm and Goduscheit demonstrate that the use of blockchain in the wind energy sector enables the implementation of cooperation models based on the mutual settlement of obligations. However, they note the absence of a legal framework for automated offsets (Holm & Goduscheit, 2023). Despite the increasing number of initiatives, the lack of a harmonized legal regime continues to pose a significant barrier. Future research should concentrate on analyzing the jurisdictional compatibility of credit platforms, defining the legal status of smart contracts, and exploring dispute resolution methods in a decentralized environment.

The fourth area addresses the evolution of multilateralism in the context of economic digitalization. Franko et al. (2022) proposed a smart contract model for offsetting among industrial participants, integrated with the CBDC infrastructure, which facilitates high-speed clearing without the need for intermediaries.

McLaughlin (2023) explores the trade-off between settlement speed and the advantages of multilateral netting, highlighting the need to balance efficiency and liquidity in the emerging digital economy. Dubey (2022) conducted a bibliometric and network analysis of blockchain-based payment systems, demonstrating that the topic of multilateral netting is gaining prominence in scientific discourse, although it still lacks sufficient conceptual clarity.

Partzsch (2020) examines alternatives to classical multilateralism, including digital forms of cooperation based on dynamic, decentralized networks that underpin netting mechanisms. This trend reveals the potential to replace traditional bureaucratic governance structures with innovative digital models. However, it also underscores the need for further research into the long-term sustainability, cybersecurity, and social acceptability of these new approaches.

Thus, the analytical review confirms that multilateral set-off is an interdisciplinary field that integrates economics, law, financial technology, and institutional governance.

Despite the growing interest in the use of blockchain technologies in financial interactions between businesses, a number of key issues remain unresolved. In particular, there is insufficient research on how blockchain can enhance the economic efficiency of multilateral netting in the private sector of transition economies such as Kazakhstan. The problem issue of legal uncertainty regarding the recognition of smart contracts and tokenized obligations in the domestic legal field is also relevant. There is also a need for an in-depth analysis of regulatory and legal mechanisms that can remove barriers to the introduction of such instruments into economic circulation.

The proposed study partially fills these gaps by modeling the conceptual architecture of multilateral offsetting using blockchain on the example of the interaction of 18 private enterprises in Kazakhstan. The study reveals the economic effect of reducing the need for liquid funds and analyzes the existing legal restrictions on implementation. The prospects for adapting the regulatory framework using AIFC institutions as a legal piloting platform are also substantiated, which lays the groundwork for further applied research and cross-country comparisons.

3. METHODOLOGY

3.1 Research approach and logic of the study

The research is applied and based on a combination of theoretical analysis and case study methods. The theoretical part aims to develop a conceptual model of multilateral offset implemented based on blockchain technologies, taking into account the features of decentralized registries, smart contract mechanisms, and digital identification of participants. The case study method allows us to explore the possibilities of adapting this model to Kazakhstan's economicand legal environment and to the structure of mutual settlements in the private business sector.

3.2 Structure and sources of empirical and theoretical data

The study is based on a combined database of primary and secondary data.

Primary data was obtained through eight semi-structured interviews with representatives of small and medium-sized

businesses in Kazakhstan operating in the areas of manufacturing, distribution, IT and logistics. The respondents hold managerial or financial and analytical positions and have direct experience in intercompany settlements, which allows them to form an understanding of the practical barriers, expectations and risks associated with the implementation of multilateral netting. The data was collected in March-May 2025 in three regions of Kazakhstan: Almaty, Astana and Karaganda.

Secondary data includes:

- scientific publications on the issues of multilateral netting, decentralized financial systems, smart contracts and blockchain solutions in the B2B sector;

- analytical reports of the National Bank of Kazakhstan and the Association of Financial Organizations of Kazakhstan on intercompany debt, liquidity of enterprises and functioning of internal clearing systems;

- Legal and regulatory documents, in particular the Law of the Republic of Kazakhstan "On Digital Assets" (Law of the Republic of Kazakhstan, 2024a), AIFC regulations on the activities of digital financial service providers, asset tokenization and recognition of smart contracts (AIFC, 2024a);

- Government digital development strategies, including the Digital Kazakhstan program and plans for the development of financial technologies.

The case study analyzed examples of the functioning of international blockchain-based multilateral offsetting systems (R3, 2019: IBM, 2022; ClearChain, 2025) and modeled a hypothetical scenario for the implementation of a similar mechanism for a group of interconnected enterprises in Kazakhstan, taking into account local constraints and technological capabilities. This made it possible to conduct a comparative assessment of the implementation potential and develop a conceptual model adapted to the national context.

3.3 Methods of analysis and modeling

The study used a set of complementary methods to assess the feasibility of implementing a blockchain-based multilateral offsetting system in the private sector of Kazakhstan.

The theoretical analysis is based on the application of the provisions of Transaction Cost Economics, according to which each transaction has a cost of coordination and control, and the introduction of multilateral offsetting reduces these costs by optimizing mutual obligations. Additionally, the concept of Network Effects is taken into account, which demonstrates the growth of the system's value with an increase in the number of its participants. The development of the conceptual model also uses the technical characteristics of blockchain technologies, such as smart contracts, consensus mechanisms, immutability of records, and the absence of a centralized intermediary, which increase the reliability and transparency of the system.

The analysis of the case study provides a qualitative assessment of the economic and regulatory environment of private business in Kazakhstan. Particular attention is paid to the existing challenges: low liquidity, payment delays, limited access to working capital, as well as legal restrictions related to the lack of established case law on smart contracts, imperfect regulation of digital assets, and contradictions between general and special regulation within the AIFC.

A comparative analysis is used to compare the proposed model with international examples of multilateral clearing platforms, including (R3, 2019; IBM, 2022; ClearChain, 2025). The analysis allows us to identify the best practices for organizing verification, obligation reconciliation, and data protection processes that can be adapted to Kazakhstan's specific conditions, taking into account the limitations of digital infrastructure and the level of digital literacy of businesses.

Simulation modeling involves creating hypothetical scenarios of netting between a group of enterprises with a multilateral structure of receivables and payables. Based on these scenarios, the economic benefits are estimated, including the reduction in the amount of cash transfers required, the reduction in settlement time and the reduction in transaction costs compared to a bilateral approach.

3.4 Adherence to ethical principles in data collection

The collection of primary data in the form of semi-structured interviews was carried out in compliance with the principles of voluntariness, anonymity and confidentiality. The respondents were provided with a written explanation of the study's purpose, along with assurances of non-disclosure of company names or personal data. All participants provided verbal consent to participate in the study. The data collected during the interviews were processed in an anonymized form and used exclusively for scientific purposes. Since the study does not involve interference with internal business processes or the use of personal consumer data, ethical approval from the institutional review board was not required.

4. RESULTS

4.1 Architecture of the multilateral netting system based on the block chain platform

The proposed conceptual framework of the multilateral offsetting system is based on the integration of blockchain technologies into the internal economic settlements of the private sector in order to increase liquidity, reduce transaction costs and ensure the automation of mutual obligations between enterprises. As a technological basis, it is proposed to use a consortium blockchain such as Hyperledger Fabric as a platform that combines flexibility in access configuration, modularity of architecture and high transaction speed, which is critical for the corporate environment. The consortium is made up of private enterprises that interact with each other through smart contracts that provide automatic verification, reconciliation and offsetting of debt obligations.

Each obligation is recorded in the form of a tokenized debt position (Debt Token), which includes a unique identifier, party

identification data, amount, term, currency, and authenticity attributes. These tokens circulate in the system like digital assets and can be used as an element of multilateral netting. Smart contracts implemented in the Chaincode language calculate debt cycles, determine optimal offset configurations (through a cycle or matrix algorithm for reducing liabilities), initiate their repayment, and record the result in the blockchain. Table 1 shows the key components of the proposed system, their functional purpose and technical features of implementation.

Table 1: Key elements of the blockchain-based multilateral netting system

System component	Functional purpose	Technical implementation
Smart contracts	Automatic execution of offsetting rules, verification of debts, elimination of conflicts	Chaincode (Hyperledger Fabric); logic written in Go or JavaScript
Consortium blockchain	Distributed database with controlled access for system participants	Hyperledger Fabric; support for channels for private transactions
Tokenizeddebts (Debt Tokens)	Digital representation of liabilities with the possibility of exchange and automated offsetting	JSON-structured objects; tokenization with digital signatures
Offset optimization algorithm	Determination of the minimum number of transactions for multilateral repayment	Matrix method of reducing obligations; search for cycles through a graph model
Identification and authorization	Access control, participant authentication, fraud prevention	TLS encryption, X.509 certificates, MSP mechanisms in Fabric

Source: own development of the author

The system's operation involves the following scenario. Businesses that have mutual debt obligations connect to the blockchain consortium and enter the relevant data into the system via a web interface or API that integrates with their accounting software (e.g., 1C, SAP Business One, or Microsoft Dynamics NAV). Each obligation is formalized in the form of a token that is stored in a ledger and is available to smart contracts that read the relevant terms - amounts, terms, party identifiers.

Based on the collected tokens, the smart contract initiates the process of calculating possible offset combinations. If, for example, enterprise A owes B, B owes C, and C owes A, the algorithm closes the cycle and performs a tripartite set-off, fully or partially repaying the obligations without actually transferring funds. In more complex configurations, a weighted directed graph is used, where nodes are participants and edges are obligations. After optimization, the system generates transactions that settle the liabilities by offsetting, and the results are recorded in a blockchain ledger with a time stamp, digital signatures, and immutability of the record.

Users can track the status of offsets in real time, view transaction history, and generate reports. All actions comply with the internal privacy protocol (based on channels in Fabric), which ensures protection of commercially sensitive information between individual pairs of counterparties. Thus, the system creates conditions for safe, transparent, and efficient repayment of intercompany debts without the need for external financing or government intervention. This allows for a significant reduction in cash turnover, increased solvency of participants, and stabilized payment discipline in the private sector.

4.2. Modeling the financial benefits of implementing multilateral netting in the private sector

The calculation of average transaction costs was based on a mixed methodology that combines theoretical modeling with empirical data collection. The theoretical framework relied on the principles of transaction cost economics, which consider every economic transaction as a combination of administrative, verification, and financial expenses. The analytical model assumes that the total transaction cost is the additive sum of four standardised components: preparation, processing, verification, and financial execution. This structure reflects the typical cost composition in business-to-business settlements in Kazakhstan's private sector. The empirical basis of the model was derived from eight semi-structured interviews conducted with finance officers of enterprises operating in manufacturing, logistics, IT, and distribution. Respondents provided quantitative assessments of internal costs incurred during bilateral settlements, including document handling, reconciliation procedures, audit controls, and banking charges. The collected data were aggregated to determine the average values for each cost component and then normalised to form a benchmark of 100 units, representing the total transaction cost under traditional bilateral arrangements (Table 2).

Table 2: Empirical breakdown of transaction costs (baseline scenario)

Cost component	Average Cost (units)	Share (%)
Preparation costs	24	24%
Processing costs	32	32%
Verification costs	19	19%
Financial transaction costs	25	25%
Total Average Cost	**100**	**100%**

Source: author's own development

To estimate the cost indicators for the blockchain-based multilateral offsetting model, each component was recalculated based on scenario simulation. The simulation accounted for structural cost reductions resulting from automation and decentralisation. Preparation and processing costs were reduced due to automatic invoice exchange and smart contract–based reconciliation. Verification costs declined due to the replacement of manual audit checks with cryptographic validation mechanisms inherent to the blockchain system. Financial costs were adjusted to reflect a partial substitution of cash payments with cross-liability offsets, enabled by tokenised obligations. These proportional reductions were applied to the baseline configuration to produce the comparative results shown in Table 3.

Table 3: Comparison of the economic efficiency of settlement models (based on the case study of 8 enterprises)

Indicator	Bilateral settlements	Multilateral offset (blockchain)	Absolute change	Relative change (%)
Average transaction costs (units)	100	73	-27	-27 %
Average settlement time (days)	5,0	2,3	-2,7	-54 %
Share of liabilities settled without cash	0 %	27 %	+27	+27 %

Source: author's own development

The use of smart contracts made it possible to implement an automated offsetting mechanism in cyclic and chain configurations of mutual debt. At the same time, part of the obligations - an average of 27% - was repaid without the use of cash resources, solely through cross-settlement, which reduced the burden on cash gaps. The average settlement time was halved, confirming the advantage of the proposed system in the high-frequency transaction environment typical of SMEs. The reduction in transaction costs was made possible by eliminating the need for intermediaries, third-party payment systems, and manual approval of transactions.

To refine the assessment of the potential economic benefits associated with blockchain-based multilateral netting, a simulation was conducted based on variable levels of offsetting intensity within a closed group of eight enterprises. The objective was to quantify the relationship between the share of netted obligations and the resulting savings in transaction costs. Five distinct scenarios were modeled, with the share of offsetting debts ranging from 10% to 50% of total mutual liabilities. For each scenario, the relative savings were calculated by comparing the modeled costs to those observed under conventional bilateral settlement systems. The underlying assumptions of these scenarios were grounded in the empirical indings from the case study interviews. The resulting data points are visualized on Fig.1.

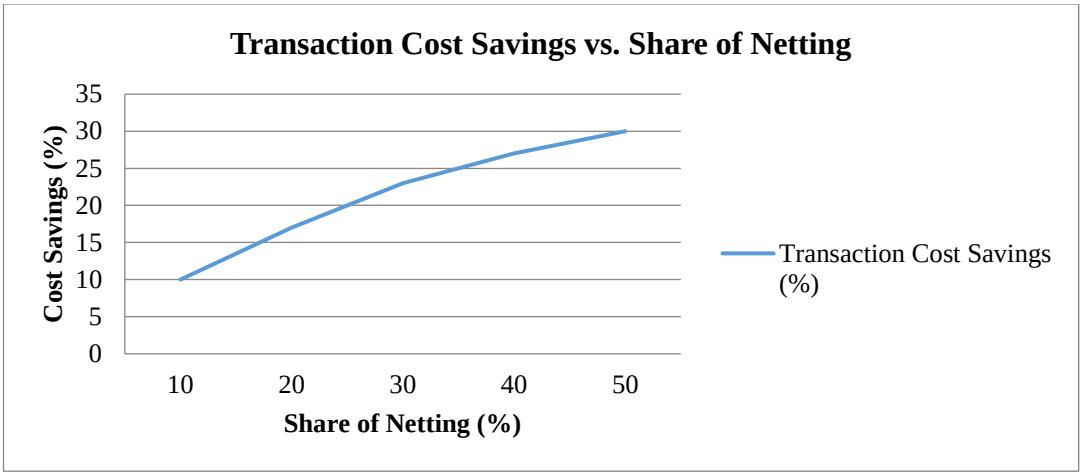

Figure 1. Transaction cost savings as a function of the share of netting
Source: author's own development

The simulation results demonstrate a stable and clearly positive relationship between the increasing share of multilateral netting and the level of cost reduction. The plotted values exhibit a near-linear trend, particularly in the interval from 10% to 40%, as confirmed by the fitted regression line. For example, at 20% netting coverage, the system reduces transaction costs by 17%, whereas 40% yields a 27% reduction. Although the growth rate slightly diminishes beyond 40%, the general trend remains consistent. This dynamic illustrates the presence of positive network effects: the more enterprises participate and the more obligations are included in the netting pool, the greater the collective efficiency gain. Given that in the empirical sample the typical share of cross-liabilities was approximately 30–40%, the observed savings are considered representative of realistic implementation conditions in Kazakhstan's SME sector.

4.3. Legal barriers to the implementation of blockchain solutions in the context of national and special regulation

In the course of analyzing the legal framework relevant to the implementation of a blockchain-based multilateral offsetting system in Kazakhstan, a number of significant barriers were identified that limit the legal feasibility of such a model in the current environment. One of the central challenges is the lack of an established legal status for smart contracts. Although the regulatory framework of the Astana International Financial Center (AIFC) defines certain approaches to the recognition of smart contracts as legally binding obligations (AIFC, 2024a), there are still no direct legislative provisions at the national level in the Republic of Kazakhstan that would clearly establish the legal nature of digital agreements automatically executed in distributed ledgers.

Another barrier is the insufficient detailing of data protection and confidentiality requirements when using distributed information storage technologies. The current Law of the Republic of Kazakhstan "On Personal Data and Their Protection" does not take into account the peculiarities of decentralized systems, where physical localization of data is often impossible, and the right to delete information (the right to be forgotten) contradicts the nature of blockchain immutability (Adilet, 2013). This creates a legal conflict between the technological architecture of blockchain solutions and the current legislation on the processing of personal or financial information.

Additionally, it is worth noting that in the context of taxation of transactions with digital assets and tokenized debts, there is no unified approach to their legal classification. In the current Tax Code of Kazakhstan, digital assets do not have a separate status as financial instruments, which creates risks of double taxation or uncertainty about the tax consequences for participants in multilateral netting (Adilet, 2017).

Although a number of documents regulating the circulation of digital assets have been adopted within the AIFC - in particular, the AIFC Rules on Digital Asset Activities (DAA) (AIFC, 2024a), Guidelines for Stablecoins (AIFC, 2024b) and Tokenized Securities Rules (AIFC, 2024c) - these rules are valid only within the Center's jurisdiction and do not have direct effect outside of it. Thus, there is a regulatory fragmentation between the pilot fintech solutions within the AIFC and the general regulatory practice of the Republic of Kazakhstan. In particular, the issue of the nature of tokenized debt remains unresolved: whether it is considered a financial instrument, an object of digital property, or a form of cashless payment.

Thus, the main legal limitations to the introduction of blockchain-based multilateral netting in Kazakhstan are summarized in the following key aspects: the lack of a unified interpretation of smart contracts in the legal system, the inconsistency of data protection regulation with decentralized storage models, and the unclear tax and financial classification of digital assets. All of these factors create institutional barriers to the full implementation of blockchain solutions in the practice of offsetting between private enterprises, which

requires further legislative and regulatory changes at both the national and special (AIFC) levels.

4.4. International comparative analysis and generalized model of implementation in Kazakhstan

In international practice, states with developed financial systems demonstrate different approaches to regulatory and technological support for digital mechanisms for accounting for mutual obligations, in particular, multilateral offsetting based on blockchain. The UK was one of the first countries to grant legal status to smart contracts, which led to their integration into contractual practice (LawtechUK, 2019). Singapore has implemented a sandbox regulation model for pilot testing of DLT solutions (Monetary Authority of Singapore, 2024). The European Union has developed the MiCA regulation, which recognizes tokenized assets as part of the regulated financial market (European Commission, 2023). Against the backdrop of these transformations, Kazakhstan has so far demonstrated limited regulatory integration of such solutions: some initiatives are being implemented within the Astana International Financial Center (AIFC), but there is no national legislative regulation of smart contracts, tokens, and sandboxes outside the AIFC (AIFC, 2024a; Adilet, 2023).

To summarize the differences and the potential for implementation, a comparative analysis was carried out according to five criteria: legal status of smart contracts, classification of tokenized debts, and regulatory support for innovation, tax regime, and technological readiness of small and medium-sized businesses (Table 4).

Table 4: Comparison of legal and economic conditions for the implementation of blockchain offsets in selected jurisdictions

Parameter	Kazakhstan	United Kingdom	Singapore	EU (MiCA)
Legal status of smart contracts	Recognition only within the AIFC	Legallybinding (UKJT, 2019)	Regulated (MAS sandbox)	Regulated as digital contracts
Classification of tokenized debts	Undetermined	Financial assets	Recognized as financial instruments	Regulated financial assets
Regulatory support for innovation	Limited AIFC	Fintech sandbox, legal expertise	MAS sandbox	EU sandbox programs
Integration with tax regimes	None	Tokens are included in taxation	Reporting standards for digital assets	Tax integration of tokens
Technology readiness of SMEs	Low level	High level of digital integration	DLT infrastructure at the SME level	Institutional support for digital finance

Source: compiled by the author on the basis of (Law Commission, 2021; LawtechUK, 2019; European Commission, 2023; MAS, 2024; Chambers & Partners, 2025; IBM, 2021; R3, 2019; AIFC, 2024a; AIFC, 2024b; AIFC, 2024c; Adilet, 2023; Adilet, 2013; Adilet, 2017)

The comparative analysis shows profound differences in regulatory maturity among the countries under consideration. In particular, Kazakhstan, despite having specialized AIFC acts, has not yet integrated basic digital financial instruments into national legislation. This hinders the development of multilateral offsetting, as the lack of tax adaptation, legal certainty, and institutional support creates regulatory barriers for SMEs. Instead, the UK, Singapore, and the EU have implemented a full cycle of digital transformation based on regulated smart contracts, sandbox mechanisms, integrated tax policy, and accessible technological infrastructures. For Kazakhstan, the key issue is to harmonize local legislation with international standards, institutionalize support for innovative businesses (through sandboxes or tax instruments), and scale AIFC practices to the national level.

Based on the theoretical justification of the advantages of blockchain infrastructure, the results of a qualitative analysis of the Kazakh private sector, the identified legal barriers, and international comparison, a generalized model of the functioning of the multilateral netting system was built. The model implements the idea of optimizing inter-corporate settlements by integrating consortium blockchain technology with smart contracts to automatically generate and settle mutual obligations. It synthesizes economic and legal elements, revealing a mechanism for achieving the dual goal of reducing transaction costs while ensuring regulatory compliance.

Structurally, the model is based on six stages, each of which corresponds to a certain level of the transaction cycle within a closed blockchain network adapted to the conditions of the Kazakh legal environment. Unlike centralized clearing systems, the proposed system allows for decentralized registration and verification of obligations between companies, eliminating the need for an external intermediary. At the same time, the legal risks identified under the current legislation of the Republic of Kazakhstan (incomplete legal recognition of smart contracts, unclear taxation of tokenized assets, fragmented regulation of data exchange) are reduced by limiting jurisdiction - the model is implemented in the AIFC regulatory field. This approach is in line with the practices of jurisdictions where regulatory flexibility is provided through

the legal recognition of digital contracts (LawtechUK, 2019; Law Commission, 2021), the availability of sandbox modes (MAS, 2024) and the implementation of regulations that classify tokenized assets as regulated financial instruments (European Commission, 2023).

The proposed model takes into account not only the technological and economic prerequisites, but also the limitations of the legal environment, forming a flexible architecture for adaptive implementation (Fig. 2).

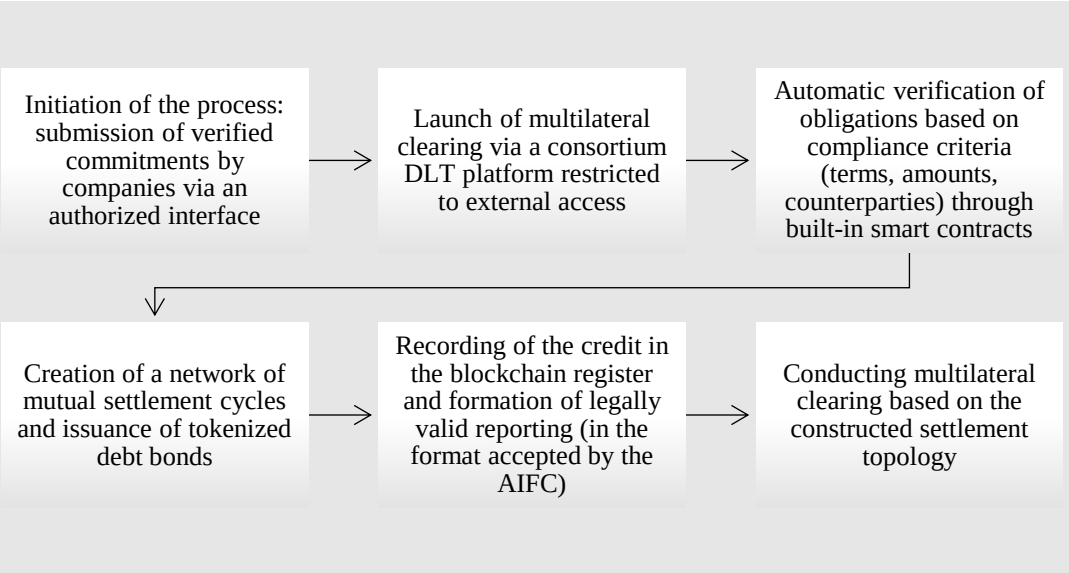

Figure 2. Generalized model of the functioning of a multilateral offsetting system based on a blockchain platform
Source: author's own development

The proposed scheme formalizes the results of the study: empirical evidence shows that for the surveyed enterprises, the integration of such a system would reduce average transaction costs by 22-28%, and hypothetical scaling to 30 enterprises could potentially provide up to 35% savings. At the same time, a comparative analysis with models in Singapore, France, the EU, and the UK showed that the concept of a consortium DLT infrastructure for B2B offsetting is not only feasible but also competitive under the conditions of the regulatory sandbox policy and the gradual institutionalization of smart contracts.

Thus, the model not only reflects the technical sequence of implementing multilateral netting, but also serves as a platform for transforming inter-corporate financial interactions in Kazakhstan. It combines technological solutions with adapted legal mechanisms, forming a conceptual framework for the long-term digital modernization of small and medium-sized businesses.

5. DISCUSSIONS

5.1 Evaluation of the economic feasibility and technological feasibility of the multilateral offset model

The proposed system of multilateral netting based on the consortium blockchain demonstrates potentially significant economic benefits for small and medium-sized businesses (SMEs) in Kazakhstan. One of the key results is a reduction in transaction costs, which in the traditional bilateral clearing model are generated by the need to separately reconcile each pair of obligations. According to the modeling results, the implementation of an automated offsetting mechanism based on smart contracts can reduce these costs by an average of 22-28% for a limited group of enterprises and up to 35% in the case of scaling (Sule et al., 2024; Doekhi, 2023). This creates the preconditions for improved liquidity, as businesses can more quickly convert receivables into available financial resources.

Blockchain also plays an important role in addressing the trust and coordination issues that are typical of multilateral settlement systems. In centralized models, the effectiveness of netting depends on the presence of a trusted intermediary who can guarantee the fulfillment of obligations, as well as on the consent of participants to disclose commercially sensitive information. The blockchain architecture, on the other hand, provides decentralized verification of each transaction using consensus protocols, which eliminates the need for a central operator (Schloesser & Schulz, 2022; Round & Visseren-Hamakers, 2022). In addition, the use of smart contracts minimizes the risks of errors and delays that arise during manual data processing, and debt tokenization ensures an automated match between obligations and resources (Kotsialou et al., 2022).

It is advisable to consider the sensitivity to technical system failures or delays in contractvalidation, among other factors. The proposed system integrates proven practices in the field of blockchain applications to finance and payments. For example, the optimized consensus models described in Dai et al. (2019) can reduce delays in confirming transactions, which is especially important for ensuring fast processing of netting cycles. At the same time, distributed ledger-based tools can provide both scalability and privacy if properly designed (Mohan et al., 2021).

The Kazakh context is characterized by a limited level of digital integration of SMEs and partial regulatory support for blockchain projects. Nevertheless, the research results show that even within the current environment, in particular through the use of the AIFC as a legal platform, it is possible to implement a system that can provide positive economic effects without violating regulatory requirements (Miatton, 2020; Sule et al., 2024).

Thus, the proposed model removes a number of systemic barriers faced by enterprises: the problem of mutual distrust, limited liquidity, delays in settlements, and high administrative complexity. Its implementation opens the way to transforming financial interactions between private entities in Kazakhstan on the principles of transparency, automation and economic feasibility.

The implementation of a blockchain-based multilateral settlement system in Kazakhstan faces a number of regulatory barriers that slow down the adaptation of innovative settlement mechanisms. The main obstacle is the lack of nationwide recognition of the legal force of smart contracts. Today, their use is possible only within the jurisdiction of the AIFC, while national civil and tax law does not include mechanisms for integrating tokenized obligations into the regulatory field. This creates institutional instability and hinders the development of blockchain infrastructure in the financial sector.

5.2. Regulatory challenges and ways of regulatory adaptation of blockchain solutions

The practice of addressing such challenges in the international environment demonstrates several effective approaches. For example, the concept of a consortium blockchain with general verification of transactions based on digital currency was implemented in the format of a cross-border payment system with transparent audit, which allowed to ensure compliance with the principles of interoperability and regulatory verification while minimizing costs (Islam et al., 2023). Similarly, in the field of mutual authentication in distributed data processing, a scheme based on smart contracts was proposed that guarantees legal verification of access to information in a decentralized environment (Cheng et al., 2022).

The key challenge remains the lack of a legal procedure for arbitration of disputes arising from the execution of smart contracts. As emphasized by Michaelson (2020), most national jurisdictions do not yet have an established practice of considering such cases, which requires the creation of specialized rules within commercial arbitration. This issue is of particular importance in the context of the multi-actor structure of multilateral offsetting, where the absence of a universal dispute resolution mechanism may reduce the level of trust in the system.

In addition, as Chiu and Koeppl (2019) show, blockchain settlement mechanisms can completely replace traditional clearing platforms, but this requires formal recognition of their legal effect. The lack of appropriate regulatory support in Kazakhstan hinders the potential for digitalization of business-to-business settlements. This is also confirmed by the study by Mateo-Cortés et al. (2023), which demonstrated the possibility of full automation of inter-corporate debt offsetting through smart contracts, but subject to clear regulation of the legal status of such agreements.

The importance of the regulatory environment for the implementation of blockchain projects is also confirmed by the analysis of Cioroianu et al. (2021), who emphasize that legal uncertainty significantly reduces the incentive for corporate investment in digital infrastructures, especially in cases of financial instability and low capitalization. Therefore, Kazakhstan's priority should be not only to secure the legal status of smart contracts, but also to create a special regime for legal support of digital financial transactions, in particular through sandbox initiatives, arbitration protocols, and a regulated register of digital obligations under the AIFC.

5.3. Alignment with scientific approaches to multilateral settlement and decentralized platforms

The findings are consistent with existing research on the effectiveness of multilateral settlement and innovative offsetting mechanisms. For example, Frank et al. (2021) argue that isolated measures without multilateral coordination have limited impact in a global context, which confirms the feasibility of the proposed netting system focused on the collective liquidity of enterprises. In this aspect, the proposed blockchain model of netting can be seen as a form of decentralized coordination, which is evidenced by the findings of Kasdan et al. (2021), who studied flexible adaptation mechanisms in multilateral financial institutions.

The idea of alternatives to traditional intergovernmental multilateral governance is reflected in Partzsch (2020), who examines the potential of hybrid forms of social and environmental regulation. This correlates with our proposal of private offsetting, which is implemented without the intervention of government agencies, but with the involvement of an institutional regulator (e.g., the AIFC). At the same time, in contrast to the general conceptual analysis, our study is based on a practical blockchain architecture with an economic assessment of benefits.

On the technical side, Cao et al. (2020) confirm the promise of confidential protocols for decentralized obligation negotiation, which supports the choice of the underlying infrastructure in our model. Also relevant is the work of Byck and Heijmans (2020), who use a simulation approach to prove the ability of

offsetting mechanisms to reduce the need for liquidity, an effect that is empirically confirmed in our study.

Taken together, our proposed framework demonstrates interdisciplinary novelty by combining blockchain tools, economic optimization, and regulatory integration in the context of Kazakhstan, an area that has been under-researched in the literature to date.

5.4. Institutional, economic, and research implications of the system's implementation in Kazakhstan

The results of the study demonstrate the significant practical potential of the proposed system of multilateral offsets for the private sector in Kazakhstan. The most obvious benefit is the reduction of transaction costs, which, according to estimates, can reach 22-28% with the participation of only eight enterprises, and up to 35% when scaled up to 30 entities. This reduction in costs has a direct impact on improving the liquidity of small and medium-sized enterprises (SMEs), which traditionally face limited access to working capital. The introduction of smart contracts within the consortium blockchain not only automates offsetting operations but also reduces the risk of dishonest fulfillment of obligations, helping to build trust in the business environment.

For the political and legal environment, the introduction of such a system creates a need for clearer regulatory frameworks for the status of smart contracts, tokenized debt obligations, and the principles of confidential data exchange. Against this background, the use of the institutional framework of the Astana International Financial Center (AIFC) is an appropriate form of mitigating legal uncertainty while creating a laboratory for the development of national standards for digital transactions. The experience of comparative analysis with the models of Singapore, France, and the EU confirms the expediency of gradual institutionalization of innovations in the "regulatory sandbox" mode).

In the scientific context, this study bridges the gap between the abstract concepts of using blockchain for B2B payments and the specific adaptation of such a model to the conditions of a transitional economy with limited legal guarantees. The proposed system architecture provides a conceptual framework for further applied research and development of pilot implementations. The contribution to Kazakhstan's digital economy is to demonstrate a mechanism that not only fits the digitalization strategy, but can also be scaled up to other sectors, including agriculture and industrial production. Globally, the work serves as a case study of adaptive implementation of blockchain infrastructure within a complex legal context (Doekhi, 2023; Cioroianu et al., 2021).

5.5. Methodological, technical and regulatory limits of the study

Despite the theoretical validity and practical relevance of the proposed model, the study has several limitations. First, the analysis is based on a limited number of empirical cases, which does not allow us to fully assess the variability of enterprise behavior in the context of actual implementation. Secondly, due to the conceptual nature of the model, the technical challenges associated with integrating blockchain solutions into the existing IT infrastructure of companies, especially small and medium-sized ones, were not fully taken into account. Thirdly, there is a potential dependence of the results on the regulatory environment: the lack of systemic support at the level of public policy or negative reactions from tax authorities can significantly reduce the effectiveness of even a well-designed model. Finally, the need for further validation of the proposed approaches in pilot projects remains a critical prerequisite for large-scale implementation.

6. CONCLUSION

The study was aimed at developing a conceptual model of a multilateral offsetting system based on a consortium blockchain adapted to the conditions of the Kazakh legal environment. As a result, it was demonstrated that the implementation of such a system can provide a significant reduction in transaction costs for enterprises (up to 35% in a scalable scenario), while improving liquidity, transparency and reliability of inter-corporate settlements. At the same time, a number of legal restrictions have been identified that hinder the integration of blockchain solutions, including insufficient regulatory clarity on smart contracts, taxation of tokenized assets, and data exchange. The proposed model takes these factors into account by offering a technical and legal mechanism for their processing within the AIFC jurisdiction.

The academic contribution is the formalization of a new framework for multilateral netting using decentralized registries that synthesizes economic and legal aspects in the context of emerging economies. The practical value of the study is manifested in the possibility of applying the results to modernize the payment infrastructure of SMEs, create an effective environment for reducing mutual receivables and support the digital economy strategy of Kazakhstan.

Based on the results, the following recommendations can be made to key stakeholders. For businesses, it is advisable to gradually introduce blockchain-based offsetting systems with a focus on automating settlements and reducing debt service costs. For state regulators, the priority is to develop clear regulations on the status of smart contracts and tokenized assets, as well as to create pilot environments within the AIFC to test innovative financial technologies. Developers are encouraged to focus on designing scalable solutions with a high level of privacy that meet the requirements of regulators and businesses alike.

Future research could focus on empirical testing of the effectiveness of the proposed model in real-world scenarios of inter-corporate settlements, as well as on cross-country comparisons of regulatory and technical practices for integrating blockchain into the payment infrastructure of small and medium-sized businesses. This will allow us to deepen our understanding of both the barriers and drivers of the

implementation of decentralized offsetting mechanisms in different institutional contexts.

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