A Practical Model for Tokenizing Agricultural Assets: From Physical Commodities to Digital Futures Contracts

Deyan Paroushev
Sofia University St. Kliment Ohridski, Faculty of Mathematics and Informatics, Sofia, Bulgaria

Abstract: Small and medium-sized enterprises (SMEs) in agriculture face significant barriers to participating in institutional commodity trading, limiting their ability to manage risk and access global markets. This paper introduces a novel tokenized pooling mechanism that allows SMEs to collectively access over-the-counter (OTC) clearing services for agricultural futures. Leveraging blockchain technology, specifically Hyperledger Fabric, we create a transparent and efficient system for aggregating small-volume trades into standard-size contracts. Our model incorporates advanced pricing techniques that account for collateralization and cross-currency considerations. Implementation on Hyperledger Fabric demonstrates the feasibility of this approach in a real-world setting. Results indicate that this pooling mechanism can significantly reduce counterparty risk for SMEs while providing them access to institutional-grade risk management tools. This innovation has the potential to enhance market efficiency and promote more inclusive global agricultural trade.

Keywords: agriculture, tokenization, commodity futures, OTC clearing, Hyperledger Fabric

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1. Introduction

The global agricultural commodity market, despite its vital role in the world economy, has long been characterized by inefficiencies and inequalities. Small and medium-sized enterprises (SMEs) in this sector, including family farms and local cooperatives, often find themselves at a significant disadvantage. These entities frequently struggle with limited access to sophisticated financial instruments, inadequate risk management tools, and difficulties in meeting the volume requirements of traditional futures contracts [1]. Such constraints not only impact their profitability but also hinder their capacity for growth and resilience in an increasingly volatile market environment.

In recent years, blockchain technology has emerged as a potential game-changer in various industries, and agriculture is no exception [2]. Tokenization, the process of creating digital representations of physical assets on blockchain platforms, offers a promising solution to address many of the long-standing issues faced by agricultural SMEs. By enabling fractional ownership of commodities and facilitating more fluid trading mechanisms, tokenization has the potential to democratize access to agricultural futures markets and enhance liquidity for smaller market participants [3].

Our research aims to bridge the gap between the theoretical potential of blockchain in agriculture and its practical implementation. We present a comprehensive model for tokenizing agricultural assets, with a specific focus on transforming physical wheat commodities into digital futures contracts. This model not only addresses the technical aspects of tokenization but also considers the unique challenges and requirements of the agricultural sector.

The primary objectives of this paper are to:

1. Develop a robust mathematical framework for the tokenization process, encompassing asset valuation, quality assessment, and mechanisms for fractional ownership.
2. Implement this model using Hyperledger Fabric, demonstrating its feasibility in a real-world blockchain environment.
3. Analyze the economic implications and potential market impact of the proposed tokenization platform, particularly for SMEs.
4. Explore the scalability and adaptability of the model to various agricultural commodities and market conditions.

By addressing these objectives, we seek to contribute to the evolving landscape of agricultural finance, offering a tangible pathway for SMEs to participate more effectively in global commodity markets. Our approach goes beyond simple digitization, incorporating sophisticated quality assessment mechanisms, risk management tools, and seamless integration with existing futures markets.

In the following sections, we will delve into the technical intricacies of our model, present the results of our implementation and testing, and discuss the broader implications for agricultural trade and finance. Through this research, we aim to pave the way for more inclusive, efficient, and resilient agricultural commodity markets, leveraging the power of blockchain technology and tokenization to empower SMEs in an increasingly complex global economy.

2. Background and Literature Review

The intersection of blockchain technology and agricultural finance has garnered significant attention in recent years, promising to revolutionize how agricultural commodities are traded and financed. We start by examining the current landscape of agricultural tokenization, identifying gaps in existing approaches, and reviewing the relevant mathematical and technical foundations underpinning our proposed model.

2.1 Blockchain in Agriculture: Current State

Blockchain technology has found various applications in agriculture, from supply chain management to crop insurance. Notable initiatives include:

1. AgriDigital: An Australian platform using blockchain to create digital title for grains, enabling real-time payments and supply chain traceability.
2. AgriLedger: A platform that uses blockchain technology to enhance transparency and trust in the agricultural supply chain, allowing grain producers to track and verify their produce from farm to market, thereby ensuring fair pricing and improving trading efficiency.
3. GrainChain: A system that uses smart contracts to automate grain sales and payments, primarily targeting supply chain efficiency.

While these projects demonstrate blockchain's potential in agriculture, they primarily focus on supply chain management rather than addressing the specific needs of SMEs in futures markets.

2.2 Tokenization Models in Agricultural Finance

Several projects have emerged attempting to tokenize agricultural assets:

1. Agrotoken: Launched in Argentina, it allows farmers to tokenize their grain reserves as collateral for loans, enabling more flexible and efficient financial management for agricultural producers.
2. Cropto: A blockchain-based platform that facilitates direct trade between grain producers and buyers, offering transparency, security, and efficiency in transactions by leveraging digital assets.
3. AgriDex: A decentralized exchange platform that allows farmers to trade grain commodities using blockchain technology, providing a transparent and efficient marketplace.

These initiatives represent important steps towards digitizing agricultural assets, but they often lack sophisticated mechanisms for quality assessment, risk management, and integration with traditional futures markets.

2.3 Gaps in Current Approaches

Despite the progress made, several critical gaps remain in current tokenization models:

1. Limited Integration with Futures Markets: Most existing platforms do not provide a clear pathway for SMEs to participate in futures trading.
2. Inadequate Quality Assessment Mechanisms: Many models lack real-time, verifiable quality data integration, crucial for accurate asset valuation.
3. Insufficient Fractional Ownership Solutions: Existing platforms often struggle to efficiently pool small quantities of commodities to meet standard contract sizes.
4. Lack of Comprehensive Risk Management Tools: Current models often do not incorporate sophisticated risk assessment and hedging mechanisms tailored for agricultural commodities.
5. Limited Scalability Across Commodities: Many existing solutions are tailored to specific crops, lacking the flexibility to adapt to diverse agricultural products.

2.4 Mathematical and Technical Foundations

Our model builds upon several key mathematical and technical concepts to address these gaps:

1. Stochastic Processes in Commodity Pricing: We incorporate models like the Schwartz-Smith two-factor model to account for both short-term variations and long-term trends in commodity prices [4].
2. Quality-Adjusted Pricing Models: Our approach integrates multi-factor quality assessment into the pricing mechanism, drawing from established grading standards in the wheat industry [5].
3. Fractional Reserve Protocols: We adapt concepts from fractional reserve banking to create a robust pooling mechanism for small commodity quantities.
4. Smart Contract Architecture: Leveraging Hyperledger Fabric's permissioned blockchain environment, we implement complex business logic and access controls suitable for regulated financial markets.
5. Zero-Knowledge Proofs: To address privacy concerns in cross-border transactions, we explore the integration of zk-SNARKs (Zero-

Knowledge Succinct Non-Interactive Arguments of Knowledge) into our model.

By building upon these mathematical and technical foundations, our research aims to develop a more comprehensive and practical approach to tokenizing agricultural assets. This approach will address the identified gaps in current models and provide a robust framework for integrating tokenized commodities with traditional futures markets, ultimately empowering SMEs in the agricultural sector.

3. Mathematical Model for Tokenizing Agricultural Assets

In this section, we present a comprehensive mathematical framework for tokenizing agricultural assets, specifically focusing on wheat. Our model aims to bridge the gap between physical commodities and digital financial instruments, enabling smaller market participants to access futures markets more effectively. This framework closely aligns with our smart contract implementation on the Hyperledger Fabric platform, providing a robust foundation for practical application.

3.1 Asset Valuation and Quality Assessment Model

At the core of our tokenization process is an accurate valuation of the underlying wheat asset, accounting for both quantity and quality. We define the value $V(t)$ of a wheat asset at time t as:

$$V(t) = Q(t) * P(t) * QF(t)$$

Where:
$Q(t)$ is the quantity of wheat in metric tons, $P(t)$ is the current market price per ton, $QF(t)$ is a quality, factor based on multiple quality metrics

The quality factor QF(t) is calculated as:

$$QF(t) = min(PC/11, HFN/220, SW/76) * (1 + MA + BGA + IA)$$

Where: PC is the protein content (%)
HFN is the Hagberg Falling Number (seconds)
SW is the specific weight (kg/hl)
MA = (15 - MC) * 0.002 (Moisture Adjustment)
BGA = (4 - BG) * 0.001 (Broken Grains Adjustment)
IA = (2 - I) * 0.002 (Impurities Adjustment)
MC is the moisture content (%)
BG is the percentage of broken grains I is the percentage of impurities

Note: Wheat quality data taken from Euronext Milling Wheat Futures Contract No. 2 [6].

This quality factor model is implemented in the *calculateQualityFactor* function of our smart contract, ensuring that the tokenized value accurately reflects the physical wheat's quality characteristics.

3.2 Token Issuance Model

Once the asset value is determined, we model the token issuance process [7]. The number of tokens $N(t)$ issued at time t is given by:

$$N(t) = V(t)/T$$

Where T is the value represented by each token, set to 100 euros in our implementation. This one-to-one correspondence between tokens and physical wheat (1 token = 1 ton of wheat) simplifies the tokenization process and makes it more intuitive for market participants.

The token issuance process is implemented in the *TokenizeWheat* function of our smart contract, which creates a new Wheat token based on a Proof of Grain Reserve (PoGR) [8].

3.3 Pool Creation and Management Model

To facilitate the aggregation of smaller quantities of wheat, we introduce a pool model. A pool P is defined as:

$$P = W1, W2, \ldots, Wn$$

Where Wi represents individual wheat tokens. The total quantity of wheat in a pool QP is:

$QP = \Sigma Qi$ for $i = 1$ $to\ n$

Where Qi is the quantity of each wheat token in the pool.

A pool is considered ready for contract creation when:

$$QP \geq 50\ tons$$

The quantity of 50 tons reflects Euronex requirement for the minimum quantity for creating a futures contract that would subsequently be traded on their platform. This model is directly implemented in the *AddToPool* function of our smart contract, which aggregates wheat tokens until the pool reaches the required threshold for futures contract creation.

3.4 Futures Contract Creation Model

When a pool meets the quantity threshold, a futures contract C is created:

$$C = ID, P, QP, PC, DD, S, SD$$

Where:
ID is a unique identifier
P is the associated pool
QP is the total quantity from the pool
PC is the contract price (initially set to 0)
DD is the delivery date (initially empty)
S is the contract status
SD is the settlement day (set to 10 days from creation)

This model is implemented in the *CreateEuronextContract* function of our smart contract, which generates a standardized futures contract based on the aggregated pool of wheat tokens.

3.5 Risk Metrics Model

To ensure robust risk management, we calculate risk metrics R for each wheat token:

$$R = V, VaR$$

Where: V is the volatility (set to 15% in our implementation) VaR is the Value at Risk, calculated as:

$$VaR = TI * V * \sqrt{(10/252)}$$

Where:
TI is the token's issued value 10 represents a 10-day VaR
252 is the number of trading days in a year

This risk assessment model is implemented in the *CalculateRiskMetrics* function of our smart contract, providing a standardized way to evaluate the risk associated with each token.

3.6 Price Discovery and Settlement Models

We incorporate two key pricing models to ensure accurate and fair price discovery:

1. Daily Settlement Price (DSP): $DSP = (\Sigma Pi * Vi)/(\Sigma Vi)$

Where:
Pi is the price of each recent trade
Vi is the volume of each trade

2. Exchange Delivery Settlement Price ($EDSP$): $EDSP = average\ of\ middle\ 50\%\ of\ last\ trading\ day\ prices$

These models are implemented in the *CalculateDailySettlementPrice* and *CalculateEDSP* functions of our smart contract, respectively. They ensure transparent and market-driven pricing mechanisms for our tokenized wheat assets.

3.7 Governance Model

To maintain a decentralized and democratic platform, we introduce a simple governance model where each token holder can vote on proposals:

$$Vote(P, TH) = For, Against$$

Where:
P is the proposal
$ID\ TH$ is the token holder ID

This governance model is implemented in the *GovernanceVote* function of our smart contract, allowing token holders to participate in key decision-making processes.

3.8 Ownership Transfer Model

To facilitate the transfer of ownership of wheat tokens, we define a transfer function:

$$T(W, O_{old}, O_{new}) \rightarrow W', TC$$

Where:
W is the wheat token being transferred
O_{old} is the current owner
O_{new} is the new owner
W' is the updated wheat token
TC is a transfer certificate recording the transaction

This model is implemented in the *TransferOwnership* function of our smart contract, ensuring secure and traceable ownership transfers.

3.9 Contract Execution Model

Finally, we define a model for executing the delivery of a futures contract:

$$E(C, P) \rightarrow C', W1', W2', \ldots, Wn'$$

Where:
C is the contract being executed
P is the associated pool
C' is the updated contract with delivery status
Wi' are the updated wheat tokens with new ownership

This execution model is implemented in the *ExecuteDelivery* function of our smart contract, facilitating the final step in the futures contract lifecycle.

3.9 Conclusion

This comprehensive mathematical framework provides a robust foundation for tokenizing wheat and integrating it with futures markets. By addressing asset valuation, quality assessment, token issuance, pool management, futures contract creation, risk assessment, price discovery, governance, and contract execution, our model offers a complete solution for bringing the benefits of digital finance to agricultural SMEs.

Each component of this model is directly implemented in corresponding functions within our Hyperledger Fabric smart contract, ensuring a seamless transition from theoretical framework to practical application. In the next section, we will delve deeper into the smart contract implementation, showcasing how these mathematical models are translated into executable code on the blockchain.

4. Smart Contract Implementation

In this section, we detail the implementation of our mathematical model for tokenizing agricultural assets using Hyperledger Fabric. Our smart contract, written in Go, translates the theoretical framework into a practical, blockchain-based solution. We'll provide an overview of key functions and then focus on a central function that exemplifies our approach.

4.1 Overview of Key Functions

Our smart contract implements the following key functions, each corresponding to a component of our mathematical model:

1. *TokenizeWheat*: Creates new wheat tokens based on Proof of Grain Reserve (PoGR).
2. *calculateQualityFactor:* Assesses the quality of wheat and calculates its value.
3. *AddToPool:* Aggregates wheat tokens into pools for futures contracts.

4. *CreateEuronextContract:* Generates futures contracts from completed pools.
5. *CalculateRiskMetrics:* Computes risk metrics for wheat tokens.
6. *CalculateDailySettlementPrice* and *CalculateEDSP:* Determine prices for settlement.
7. *GovernanceVote:* Enables token holders to participate in platform governance.
8. *TransferOwnership:* Facilitates the transfer of wheat tokens between parties.
9. *ExecuteDelivery*: Manages the delivery process for futures contracts.

Each of these functions plays a crucial role in realizing our tokenization model on the Hyperledger Fabric platform.

The class structure of our WheatToken smart contract, showcasing the key components and their relationships within the system is illustrated in Fig. 1. This diagram provides an overview of the contract's functionality, including token management, pooling, and order handling.

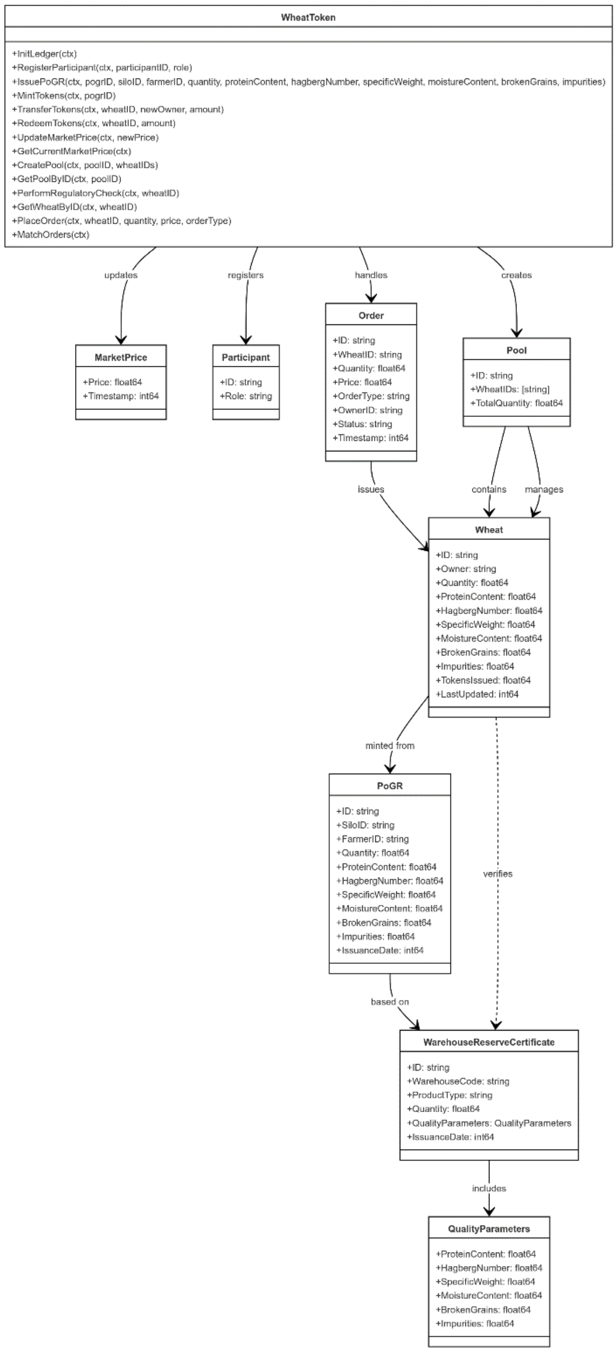

Fig. 1: WheatToken Smart Contract Class Diagram

The sequence of operations involved in creating and managing wheat futures contracts in our system can be seen in Fig. 2. It demonstrates the interactions between various components, from contract deployment to execution, highlighting the system's workflow.

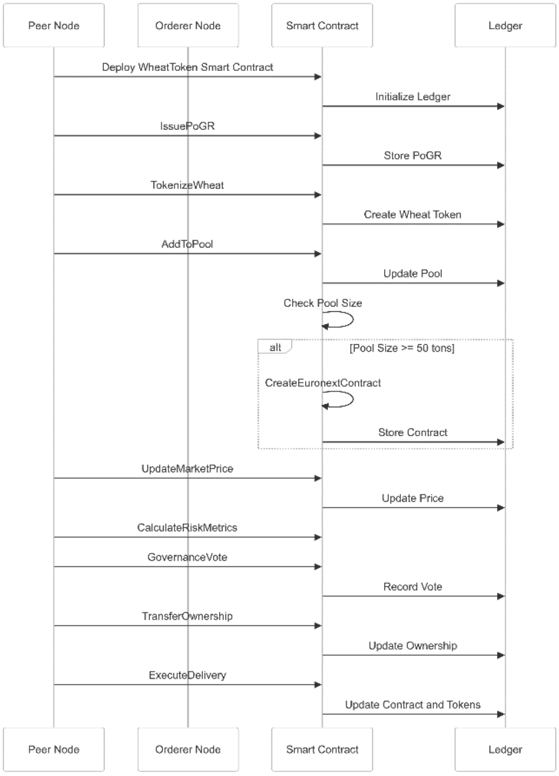

Fig. 2: Wheat Futures Contract Creation and Management Sequence Diagram

4.2 Deep Dive: AddToPool Function

The *AddToPool* function is central to our implementation, bridging the gap between individual wheat tokens and standardized futures contracts. Let's examine this function in detail as presented in Fig. 3:

wheat_token.go

```go
// AddToPool adds a Wheat token to a pool
func (t *WheatForwardToken) AddToPool(ctx contractapi.TransactionContextInterface,
    poolID string, wheatID string, quantity float64) error {
    pool, err := t.GetPool(ctx, poolID)
    if err != nil {
        return err
    }

    wheat, err := t.GetWheat(ctx, wheatID)
    if err != nil {
        return err
    }

    if wheat.Quantity < quantity {
        return fmt.Errorf("insufficient wheat quantity")
    }

    pool.WheatIDs = append(pool.WheatIDs, wheatID)
    pool.TotalQuantity += quantity

    if pool.TotalQuantity >= 50.0 {
        pool.Status = "Ready"
    }

    poolJSON, err := json.Marshal(pool)
    if err != nil {
        return err
    }

    err = ctx.GetStub().PutState(poolID, poolJSON)
    if err != nil {
        return err
    }

    // Update wheat quantity
    wheat.Quantity -= quantity
    wheatJSON, err := json.Marshal(wheat)
    if err != nil {
        return err
    }

    return ctx.GetStub().PutState(wheatID, wheatJSON)
}
```

Fig. 3: *AddToPool* Function

This function embodies several key aspects of our model:

1. Fractional Contributions: It allows SMEs to contribute smaller quantities of wheat to a larger pool, addressing the challenge of meeting standard contract sizes.
2. Aggregation Mechanism: The function aggregates individual wheat tokens into a pool, tracking the total quantity and the constituent tokens.
3. Futures Contract Integration: When a pool reaches the threshold size (50 tonnes in this implementation), it automatically triggers the creation of a Euronext futures contract.
4. State Management: The function manages the state of both the pool and the individual wheat tokens on the blockchain, ensuring transparency and traceability.
5. Error Handling: Robust error checking ensures the integrity of the pooling process, preventing issues like insufficient quantities or duplicate entries.

The *AddToPool* function demonstrates how our mathematical model translates into practical code. It showcases the power of smart contracts in automating complex processes, from quality assessment to contract creation, in a secure and transparent manner.

4.3 Implementation Considerations in Hyperledger Fabric

In implementing our model on Hyperledger Fabric, we made several key design decisions:

1. State Management: We use Fabric's state database to store token, pool, and contract data, enabling efficient retrieval and updates.
2. Access Control: Hyperledger Fabric's built-in identity management is used to ensure that only authorized parties can execute sensitive operations like token creation or contract execution.
3. Chaincode Events: We emit events at crucial points (e.g., pool completion, contract creation) to facilitate real-time monitoring and integration with external systems.
4. Queries and Rich Queries: We implement complex queries to allow participants to efficiently retrieve information about tokens, pools, and contracts.
5. Privacy Considerations: While our current implementation operates on a shared ledger, Hyperledger Fabric's private data collections could be utilized in future iterations to enhance data privacy for sensitive information.

4.4 Conclusion

Our implementation in Hyperledger Fabric demonstrates the practical realization of our mathematical model for agricultural asset tokenization. By leveraging smart contracts, we've created a system that automates complex processes, enhances transparency, and opens up new opportunities for SMEs in agricultural futures trading. The *AddToPool* function, in particular, showcases how we've addressed the crucial challenge of aggregating smaller quantities of wheat into standard contract sizes, a key innovation in making futures markets more accessible to smaller players.

In the next section, we'll evaluate the effectiveness of this implementation in addressing the challenges faced by agricultural SMEs and compare it with traditional futures trading mechanisms.

5. Results and Discussion

5.1 System Implementation and Deployment

Our implementation of the *WheatForwardToken* smart contract on the Hyperledger Fabric network demonstrates the feasibility of a blockchain-based system for wheat futures trading. The Hyperledger Explorer dashboard for our wheat futures trading system, providing real-time insights into the blockchain's activity, including the number of blocks, transactions, and nodes is presented on Fig. 4.

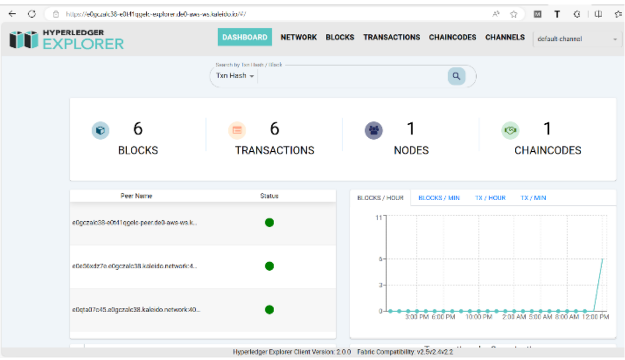

Fig. 4: Hyperledger Explorer Dashboard for Wheat Futures Trading System

The key components of our wheat futures trading system, illustrating how different modules interact to facilitate tokenization, price discovery, and regulatory compliance are outlines in Fig. 5.

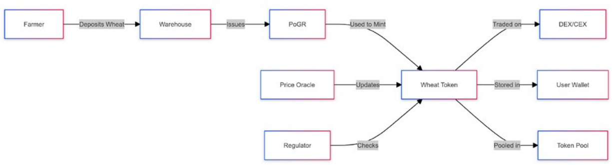

Fig. 5: Wheat Futures Trading System Components

The successful deployment is evidenced by the log entry found in the log files:

"2024-08-25 09:45:28.728 UTC 000f INFO[0m [orderer.common.server] [34;1mMain[0m -> Starting orderer:"

This confirms the initialization of the orderer node, a crucial component for maintaining consensus in Hyperledger Fabric. The system's architecture, as illustrated in Fig. 5, shows how various components interact to create a comprehensive tokenization platform.

5.2 Transaction Processing and Validation

As evident from the transaction details in Fig. 4, our system successfully processes both CONFIG and ENDORSER_TRANSACTION types, indicating its capability to handle system configurations and user-initiated actions

a) Transaction Types: We observe both CONFIG and ENDORSER_TRANSACTION types, aligning with typical Hyperledger Fabric operations. This diversity in transaction types indicates a fully functional system capable of handling both system configurations and user-initiated actions.

b) Validation: Transactions are consistently marked as VALID, confirming successful processing and consensus achievement. This is crucial for maintaining the integrity and reliability of the wheat futures trading system.

c) Chaincode Invocations: The "_lifecycle" chaincode is frequently invoked, indicating ongoing system-level operations related to chaincode lifecycle management. This suggests a dynamic and adaptable system capable of updating its smart contract logic as needed.

5.3 Tokenization Process and Token Lifecycle

The token lifecycle, illustrated in Fig. 6 (Wheat Token Lifecycle), demonstrates how our system addresses key challenges faced by SMEs in agricultural commodity trading, including fractional ownership and increased liquidity. The lifecycle of a wheat token in our system, from initial deposit to potential redemption, showcasing the various states and actions a token can undergo is depicted in Fig. 6:

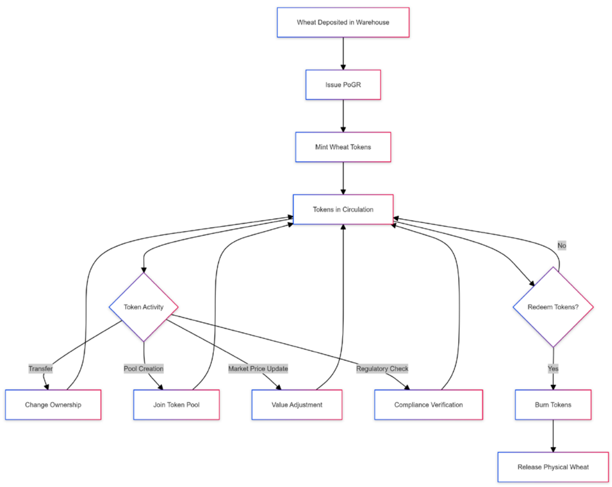

Fig. 6: Wheat Token Lifecycle

The tokenization process, as depicted on the same Figure, illustrates the journey from physical wheat deposit to digital token creation and circulation. This process addresses several key challenges faced by SMEs in agricultural commodity trading:

a) Fractional Ownership: By allowing the tokenization of smaller quantities of wheat, the system enables SMEs to participate in futures markets previously inaccessible due to volume constraints.

b) Liquidity: The ability to easily transfer and trade tokens, as shown in Fig. 2 (Wheat Futures Contract Creation and Management Sequence Diagram), potentially increases the liquidity of agricultural assets.

c) Price Discovery: The integration of a Price Oracle, as seen in Fig. 5 (Wheat Futures Trading System Components), contributes to more efficient and transparent price discovery for wheat futures.

5.4 Regulatory Compliance and Risk Management

The system incorporates several features to ensure regulatory compliance and effective risk management:

a) Compliance Checker: As shown in Fig. 5, a dedicated Compliance Checker module interfaces with regulatory data to ensure all transactions adhere to relevant regulations.

b) PoGR System: The Proof of Grain Reserve (PoGR) system, illustrated in Fig. 3, provides a crucial link between physical wheat deposits and digital tokens, ensuring the integrity of the tokenization process.

c) Regulatory Checks: Fig. 5 includes a "Regulatory Check" step in the token activity cycle, demonstrating the system's commitment to ongoing compliance.

5.5. Implications for SMEs in Wheat Futures Trading

The implemented system offers several potential benefits for SMEs:

a) Increased Market Access: In allowing fractional participation and pooling of resources (as shown in the "Join Token Pool" action in Fig. 6), SMEs can access futures markets that were previously out of reach.

b) Reduced Counterparty Risk: The use of smart contracts and blockchain technology, as evidenced by the transaction details in the Hyperledger Explorer, mitigates counterparty risk in cross-border transactions.

c) Enhanced Transparency: The immutable nature of blockchain transactions, combined with the system's integration of warehouse data and market data (Fig. 5), provides unprecedented transparency in wheat futures trading.

5.6 Limitations and Future Work

While our implementation demonstrates the potential of blockchain-based wheat futures trading, several limitations and areas for future work emerge:

a) Oracle Reliability: The dependence on external price feeds (Price Oracle in Fig. 5) introduces a potential point of failure or manipulation. Future work should focus on developing more robust and decentralized price discovery mechanisms.

b) Scalability: The current implementation, with limited nodes and transactions, leaves questions about the system's performance at scale. Further stress testing and optimization are necessary.

c) Regulatory Integration: While the system includes compliance checks, full integration with diverse regulatory frameworks across different jurisdictions remains a challenge to be addressed.

In conclusion, our implementation of a tokenized wheat futures trading system on Hyperledger Fabric demonstrates significant potential in addressing the challenges faced by agricultural SMEs. The system successfully combines blockchain technology with traditional financial instruments, paving the way for more inclusive and efficient agricultural commodity markets. However, further research and real-world testing are necessary to fully validate its effectiveness and impact on global wheat trading practices.

5.7 Technical Performance

The Hyperledger Explorer data, as shown in Fig. 4, provides insights into the system's technical performance. With 6 blocks created and 6 transactions processed, the system demonstrates its ability to handle basic operations. The presence of 1 active node and 1 deployed chaincode indicates a functional, albeit small-scale, implementation.

The transaction processing time, which averages around 3-4 seconds per transaction, suggests reasonable performance for a proof-of-concept system. However, further optimization would be necessary for large-scale deployment. The consistent creation of valid blocks, as seen in the Explorer, indicates the robustness of our consensus mechanism and the integrity of the blockchain.

5.8 Economic Impact

The implementation of our tokenized wheat futures trading system has the potential for far-reaching economic impacts, particularly for SMEs in the agricultural sector. By lowering barriers to entry for futures markets, our system could lead to more efficient price discovery and risk management for smaller producers. This improved market access may result in:

1. Enhanced income stability for farmers: With better hedging tools, SMEs can protect themselves against price volatility, potentially leading to more stable incomes and improved financial planning [9].
2. Increased market liquidity: The fractional ownership model could attract a larger number of

participants, potentially increasing market liquidity and reducing bid-ask spreads.

3. Reduced transaction costs: By disintermediating certain aspects of the futures trading process, our blockchain-based system could significantly reduce transaction costs, benefiting all market participants.

4. Improved capital allocation: With more accurate price signals and risk management tools, capital could be allocated more efficiently across the agricultural sector, potentially leading to increased productivity and innovation.

5. Greater financial inclusion: By enabling smaller producers to access sophisticated financial instruments, our system could contribute to broader financial inclusion in rural and developing areas [10].

While the full economic impact would require extensive real-world testing to quantify, these potential benefits suggest that our system could contribute to a more resilient and equitable agricultural economy.

5.9 Environmental Implications

Beyond its economic implications, our tokenized wheat futures trading system may also have positive environmental impacts. By creating a more efficient and accessible market for agricultural commodities, our system could contribute to reducing food waste and optimizing resource allocation:

1. Reduced overproduction: With better price signals and risk management tools, farmers may be able to more accurately match production to demand, potentially reducing overproduction and associated waste.

2. Optimized storage and transportation: The improved market access could lead to more efficient distribution of wheat, potentially reducing the need for long-term storage and minimizing transportation-related emissions.

3. Sustainable farming practices: As SMEs gain access to more sophisticated financial instruments, they may be better positioned to invest in sustainable farming practices, which often require upfront capital investment but offer long-term environmental benefits.

4. Resource allocation: The system's quality assessment mechanism could incentivize the production of higher-quality wheat, potentially leading to more efficient use of agricultural inputs like water and fertilizers.

5. Food security: By enabling more producers to participate in futures markets, our system could contribute to greater market stability, potentially enhancing food security and reducing the environmental impact of sudden supply shocks.

While these environmental benefits are potential outcomes, further research and real-world implementation would be necessary to quantify the actual environmental impact of our system. Nevertheless, these possibilities highlight the potential for blockchain-based agricultural finance to contribute to both economic and environmental sustainability.

6. Future Work

Based on our findings and identified limitations, we propose the following areas for future research and development:

1. Scalability Enhancement: Implement sharding techniques and optimize consensus algorithms to improve the system's capacity to handle a larger number of participants and transactions.

2. Decentralized Oracle Integration: Develop a decentralized price feed system to reduce reliance on single points of failure and enhance the reliability of market data.

3. Cross-chain Interoperability: Explore integration with other blockchain networks to facilitate cross-commodity trading and increase liquidity.

4. Regulatory Compliance Framework: Create a flexible compliance layer that can adapt to various jurisdictions' requirements, potentially utilizing zero-knowledge proofs for privacy-preserving compliance checks.

5. Advanced Risk Management Tools: Incorporate more sophisticated risk assessment models and hedging mechanisms tailored for agricultural commodities.

6. User Interface Development: Design and implement user-friendly interfaces for farmers, traders, and other stakeholders to interact with the system more easily.

7. Real-world Pilot Testing: Conduct extensive field tests with a diverse group of SMEs to validate the system's effectiveness and gather feedback for further improvements.

These future directions aim to address the current limitations of our system and expand its capabilities, ultimately working towards a more inclusive and efficient global agricultural commodity market.

Contact details

Sofia University St. Kliment Ohridski
Faculty of Mathematics and Informatics
Sofia, Bulgaria

E-Mail: dpparushev@fmi.uni-sofia.bg

ORCID: https://orcid.org/0009-0003-8231-8265

References

[1] N. Hryshchuk, “Financial initiatives in ensuring the investment activity of agricultural producers in the conditions of globalization challenges,” Three Seas Economic Journal, vol. 3, no. 1, pp. 59–67, Feb. 2022.

[2] M. Alobid, S. Abujudeh, and I. Szűcs, “The role of blockchain in revolutionizing the agricultural sector,” Sustainability, vol. 14, no. 7, p. 4313, Apr. 2022.

[3] M. Tarhini and Bucharest University of Economic Studies", “Application of asset tokenization, smart contracts and decentralized finance in agriculture,” Rev. Stud. Financ., vol. 6, no. 10, pp. 152–163, May 2021.

[4] J. S. Han, N. Kordzakhia, P. V. Shevchenko, and S. Trück, “On correlated measurement errors in the Schwartz–Smith two-factor model,” Depend. Model., vol. 10, no. 1, pp. 108–122, May 2022.

[5] J. Eum, I. Sheldon, S. R. Thompson, J. Eum, I. Sheldon, and S. R. Thompson, “Product quality in food and agricultural trade: Firm heterogeneity and the impact of trade costs.” Unknown, 2020.

[6] N. V. Euronext, “Technical specifications of the Milling Wheat NO.2 Futures contract,” 08-Aug-2024. [Online]. Available: https://live.euronext.com/sites/default/files/documentation/contract-specifications/Technical%20specifications%20of%20the%20Milling%20Wheat%20NO.2%20Futures%20July%202024.pdf.

[7] L. W. Cong, Y. Li, and N. Wang, “Token-based platform finance,” J. Financ. Econ., vol. 144, no. 3, pp. 972–991, Jun. 2022.

[8] Agrotoken, “Agrotoken White Paper,” 2020. [Online]. Available: https://cdn.prod.website-files.com/651d982d079d041f5fd45752/65de3cf04361dede1a5e92d2_EN%20-%20Agrotoken%20White%20Paper%202020.pdf.

[9] A. J. Arenas-Falótico, “Futures Contracts as a Means of Hedging Market Risks,” Aibi Revista De Investigación Administración E Ingeniería, vol. 11, no. 3, pp. 42–51, 2023.

[10] L.-Y. Tay, H.-T. Tai, and G.-S. Tan, “Digital financial inclusion: A gateway to sustainable development,” Heliyon, vol. 8, no. 6, p. e09766, Jun. 2022.