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The Chinese Path to Risk Tokenization: A Preliminary Study of Catastrophe Insurance Risk Diversification Models

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Abstract. Against intensifying extreme climate events, China's catastrophe insurance system faces a structural dilemma of "high losses yet low coverage". Traditional catastrophe risk securitization helps diversify risks but is hindered by high issuance thresholds, long cycles, and slow claims, failing to cover the large long-tail agricultural disaster-affected population. As a digital upgrade, risk tokenization improves efficiency via smart contracts and parametric triggers, yet international models relying on public blockchains and stablecoins suffer from unclear legality, weak investor protection, and threats to monetary sovereignty, making direct import unfeasible. This paper analyzes the international platform Nayms and uses Hainan's 2024 tilapia crisis triggered by Typhoon Yagi as evidence to explore a "compliant Chinese path" for risk tokenization balancing efficiency and financial security. It proposes and simulates the "Digital RMB Consortium Blockchain Catastrophe Bond Voucher" model: replacing USD stablecoins with digital RMB, anonymous public chains with regulatory consortium blockchains, and liquid tokens with locked vouchers. Smart contracts enable automatic payouts with regulatory circuit breakers, forming a "code plus human oversight" dual governance. This localized innovation retains global strengths including risk atomization, parametric automation, and T+0 settlement while enabling full central bank monitoring to safeguard monetary sovereignty and compliance. It offers an exploratory paradigm for China's "strongly regulated, efficient, and sovereign-controlled" fintech system under the socialist market economy.

Keywords: Risk tokenization, catastrophe bonds, risk securitization, smart contracts, digital renminbi, parametric insurance

1 Introduction

China's catastrophe insurance faces structural difficulties with a huge protection gap. The "high loss, low coverage" pattern arises from three bottlenecks: limited risk diversification channels and low capital market participation; low capital efficiency with illiquid traditional catastrophe bonds and high thresholds; and delayed claims failing post-disaster reconstruction needs. Meanwhile, a nationwide catastrophe

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insurance system is lacking, and regional pilots have limited effects [1]. Flood and drought catastrophe insurance legislation lags with an incomplete institutional framework [2], and missing meteorological and disaster data-sharing mechanisms restrict product pricing and claims assessment. Risk tokenization offers new solutions by reducing costs and improving efficiency through atomic segmentation, smart contract execution and real-time settlement. However, it faces unclear legal status, potential risk contagion and possible financial exclusion. Balancing technological efficiency and institutional risks is urgent under the high-level socialist market economy. Taking Hainan's Typhoon Yagi and tilapia industry as a case, this paper constructs a "Digital RMB – Catastrophe Bond – Consortium Chain" scheme for catastrophe risk diversification innovation.

2 Literature Review

2.1 Research Background: The Development Process of Risk Tokenization

This section reviews the three-stage evolution of risk tokenization. The germination period from 2014 to 2017 laid its technological foundation: Nakamoto (2008) proposed blockchain financial applications in the Bitcoin white paper, forming the theoretical basis of risk tokenization [3]; blockchain's cryptographic proof realizes trustless risk transfer disintermediation, with its immutable structure supporting parametric claims and incentive mechanisms ensuring orderly participation, while Buterin (2014) introduced Ethereum and Turing-complete smart contracts, driving the shift from programmable money to programmable finance as critical infrastructure [4], and his DAO concept provided the governance framework for decentralized insurance protocols.

From 2018 to 2020, the exploration stage saw the emergence of DeFi insurance represented by Nexus Mutual, the first Ethereum-based decentralized mutual insurance protocol [5], which adopted a mutual structure, NXM token staking, dynamic pricing, community claim voting, surplus sharing, and intermediary-free on-chain risk transfer.

Entering the maturity stage from 2021 to 2023, risk tokenization expanded diversely: the Re platform launched reinsurance risk tokenization funds with low thresholds and high liquidity, debuting on Avalanche in 2024 yet conflicting with mainstream regulation due to the absence of licenses and supervision [6]; Nayms, the world's first regulated and licensed platform approved by the Bermuda Monetary Authority, issued ILW tokens, integrating licensed operation with blockchain efficiency and legally safeguarding investors' rights under Bermuda insurance law.

2.2 Current Research Status: From Improving the Efficiency of Risk Tokenization to Exploring Compliance Paths

The evolution of asset tokenization represents a deepening of financial system functions, progressing from Real-World Asset Tokenization (RWA) that monetizes assets to risk tokenization that addresses dynamic risk transmission under extreme uncertainty, thereby enhancing the financial system's risk allocation capacity and establishing a dynamic, efficient, and transparent risk diversification mechanism. RWA focuses on improving asset liquidity by converting real-world value-bearing assets and expected cash flows into programmable, tradable, and divisible digital assets through blockchain; the BIS notes that it can eliminate credit risk and settlement delays, enable round-the-clock trading and asset fragmentation [7], while the Boston Consulting Group identifies its core as unlocking illiquid asset value and alleviating traditional finance liquidity shortages [8]. Risk tokenization centers on liability hedging and dynamic risk transfer, translating future uncertain risk exposures into programmable digital contracts to form efficient risk diversification arrangements; the OECD indicates that combining smart contracts and blockchain allows automatic data-driven pricing and compensation, real-time on-chain recording of underlying data, accelerated risk information transmission, and dynamic real-time risk diversification among investors [9]. The two differ fundamentally: in underlying assets, RWA targets positive-yield assets with certain future cash flows, whereas risk tokenization corresponds to negative risk and risk premiums. Technically, RWA's smart contracts focus on transaction execution and ownership confirmation, with its architecture involving off-chain packaging, oracle information bridging, and token issuance and compliance processing, aiming to resolve on-off chain asset correspondence and dual ownership issues [10]; risk tokenization prioritizes parametric triggering and smart contract automated payout, using oracle input to build decentralized real-time dynamic risk transfer. Systemically, RWA mitigates frictions such as slow circulation and poor liquidity, while risk tokenization transmits systemic risks like extreme catastrophes to investors with varying risk appetites, systematically enhancing the resilience of the overall economic foundation.

2.3 Commentary and Development Outlook

When facing major catastrophe risks, traditional insurance is constrained by capital, giving rise to risk securitization. The rapid development of the digital economy and the inefficiency and high costs of traditional securities have further driven the evolution from risk securitization to risk tokenization.

Risk securitization involves insurers or reinsurers setting up an SPV to package catastrophe or longevity risks into tradable bonds or derivatives, transferring insurance risks to capital markets [11], with its core strength being access to broader capital market funds [12]. Risk tokenization, enabled by blockchain, converts real or virtual risks into programmable, divisible, tradable digital protection contracts [13]; according to Nadcab (2024), it can tokenize reinsurance contracts and catastrophe bonds to achieve fragmented risk ownership and secondary market trading.

Risk tokenization reconstructs rather than replaces risk securitization at the infrastructure level. Technically, risk securitization relies on SPVs, trusts, ratings and traditional financial systems with mature laws; risk tokenization is based on blockchain and smart contracts, featuring real-time transparent records but facing smart contract and oracle risks [14]. In risk transfer, risk securitization transfers risks off-balance sheet via SPVs, while risk tokenization supports continuous secondary trading and dynamic risk bearers. For trading and settlement, risk securitization mainly serves institutional investors with T+1 or longer cycles and limited liquidity, whereas risk tokenization enables 24/7 trading, T+0 near real-time atomic settlement and lower thresholds [15]. In trigger mechanisms, risk tokenization deeply integrates parametric triggers via oracles, enabling automatic smart contract payouts without manual loss assessment.

Risk securitization enjoys high legal certainty, a mature institutional investor base and no extreme technical network risks, but suffers from high issuance thresholds, poor tail-risk coverage and high claims frictions that reduce relief efficiency. Risk tokenization provides high liquidity, rapid credit penetration and instant disaster-time claims via atomic settlement, solving the post-catastrophe funding gap and reducing moral hazard through on-chain traceability; however, it faces high regulatory uncertainty, compliance risks, smart contract vulnerabilities, ambiguous legal ownership and unclear rights between token holders and underlying risks.

3 International Case Analysis - Nayms Florida Hurricane ILW (2024)

3.1 Pain Points of Traditional Industries and Case Background

On the eve of the 2024 Florida hurricane season, Nayms launched the world's first licensed tokenized ILW product, attempting to address the above-mentioned pain points through blockchain technology. This product converts hurricane risk into digital tokens that can be traded on Ethereum Layer 2, lowers the investment threshold to several thousand dollars, achieves T+0 liquidity, and automates payout execution through smart contracts.

3.2 Product Design and Mechanism [16]

Product Architecture. As shown in **Table 1.**

Table 1. Nayms Florida Hurricane ILW (2024) Product Specifications

Parameter	Design
Underlying risk	Florida Named Windstorms Catastrophic Losses
Trigger condition	Two separate named storms occurred, and each storm individually met the loss/intensity threshold stipulated by the agreement
Insurance Term	Short-term catastrophe reinsurance contracts, adapted for Florida's 2024 hurricane season
Token Standard	ERC-20 (Base chain)
Settlement currency	USDC stablecoin
Legal structure	Bermuda split account

The Nayms Florida Hurricane ILW (2024) underlying risk coverage area covers the entire hurricane season in the most hurricane-prone areas in the United States. The trigger condition is the specified amount of loss caused by two independent storms, which reduces the basis risk of a single event and improves the efficiency of risk transfer. The token is ERC-20, compatible with the Ethereum ecosystem, ensuring security and reducing costs and increasing efficiency. And choose to settle in stablecoins, the fiat currency pegging characteristics of stablecoins can effectively reduce their exchange rate fluctuations and ensure the settlement process. Finally, the project is the world's first licensed catastrophe risk tokenization platform, licensed by the Bermuda Monetary Authority (BMA), an authoritative regulatory body that can more effectively protect the rights and interests of investors, policyholders, and asset segregation and bankruptcy protection when necessary.

1.Trigger judgment and automatic compensation

Trigger the payout condition→ Smart contract automatic execution: calculate the total payout amount, and the remaining funds will be returned to the investor in proportion to the token.

Smart contract automatic execution without triggering compensation conditions→ automatically unlocks USDC, returns investors' principal, and distributes profits.

Technical architecture.

1. Core underlying layer: Parametric insurance smart contract architecture based on Ethereum

The underlying layer of the contract is compatible with Ethereum and deployed on the Base chain (Ethereum Layer 2), taking into account the low cost and high settlement efficiency of on-chain transactions, and adapting to the needs of high-frequency transfer and automatic settlement of insurance funds. The core logic of the contract is "automatic execution of trigger condition quantification", which does not require manual intervention throughout the process. The contract is linked to the Bermuda regulatory isolated account on-chain, and all funds (investor's USDC principal) are triggered by the contract, and the flow of account funds can be traced on-chain to ensure the safety of investors' funds to the greatest extent.

2.P-Tokens (risk tokens) and contract operation rules

Issuance mechanism: Issued separately by the segregated account (entity) that manages the Hurricane ILW product, only the risk-bearing share of the product is independent of the P-Tokens of other products on the Nayms platform.

Exchange and locking: After investors transfer USDC to the contract, the contract mints and issues the corresponding amount of P-Tokens 1:1, and automatically locks the USDC principal. P-Tokens are only on-chain share certificates and cannot be transferred, traded, or destroyed during the lock-up period (hurricane season), and are completely bound to the principal lock-up state.

Core functions: P-Tokens are the only basis for the contract to identify investors' income distribution and loss bearing ratio, and each P-Token corresponds to $1 of risk exposure and income rights, and the total issuance amount is exactly the same as the total collateral principal locked in the contract.

Settlement and destruction: After the hurricane season, the contract completes the settlement of principal, income, and compensation, and automatically destroys all P-Tokens in circulation, and is irreversible to avoid the risk confusion caused by subsequent token circulation.

3.On-chain triggering and automatic settlement mechanism

Trigger condition docking: In order to ensure data security, the blockchain cannot directly access external data, so the contract reserves an oracle interface, which can access the standardized data of authoritative meteorological/loss data institutions (such as NOAA), and the conditions such as "named storm number, single loss ≥10 billion USD" of Hurricane ILW are automatically verified and determined by the oracle after pushing data to the contract, triggering the compensation logic, without manual review, accurate and fast loss settlement; Different from decentralized oracles, Naymsc uses authorized oracles, and the data is provided by a single authority, which is more professional and legally recognized, and is more suitable for professional assessment of catastrophe damage.

Untriggered Compensation (No Risk): After the contract verification trigger conditions are not met, the process of "unlocking all USDC principal and accruing premium income" is automatically executed, transferring the principal and income to the corresponding wallet according to the proportion of P-Tokens held by investors, and destroying P-Tokens after completion to prevent confusion between tokens from different projects.

Trigger Compensation (Risk): After the contract verification conditions are met, the process of "deducting USDC principal according to the agreed proportion" is automatically executed, the deducted funds are transferred to the reinsurer's account, and the remaining principal is returned to investors in the proportion of P-Tokens.

Settlement Currency: The contract only supports US dollar stablecoin (USDC) as the settlement medium, and all principal, profit, and compensation transfers are completed in USDC.

Smart contract operation logic. (As shown in Fig. 1)

1.Product initiation and token issuance

The Nayms team (licensed insurance manager) → design product parameters (trigger conditions, duration, benefits, etc.), →report to the Bermuda Monetary Authority (full supervision), → deploy smart contracts on the Ethereum base chain → issue P-Tokens tokens.

2.Investors participate in capital lock-up

Qualified investors → subscribe for P-Tokens tokens with USDC (stablecoin) after completing identity verification→ Fund allocation (allocation - smart contract lock (risk reserve) / premium income (distributed to initiators and early investors) / additional (token rewards).

Investors receive → corresponding amount of P-Tokens (representing risk exposure and income rights)

3.Risk detection and data chaining

hurricane event, third-party data agencies release damage assessments→ Nayms authorizes oracles to put the data on the chain → Smart contract automatic verification.

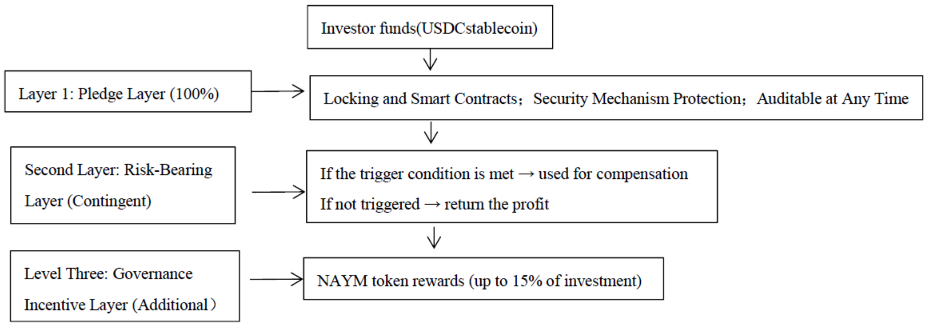

Fig. 1. Revenue Structure

3.3 The Core Logic and Characteristics of Insurance Risk Tokenization in Nayms

Parametric Triggers Replacing Subjective Loss Assessment. Nayms uses objective parameters such as 'Double Hurricane > $10 billion' to replace the traditional insurance process from loss assessment to claims. This design can eliminate moral hazard and loss assessment costs, but the disadvantage is a relatively high basis risk (the parametric trigger may not match the actual loss).

Investors Actively Assume Risk. Nayms investors' USDC is directly locked in smart contracts, and when the trigger conditions are met, the principal is used for compensation (tokens become zero). This is fundamentally different from traditional financial products with fluctuating returns and principal protection, reflecting the core principle of symmetric risk and return in risk tokenization.

Automated Efficiency of Real-Time Claims Via Smart Contracts. Nayms compresses the claims process from the traditional ILW's 6-12 months to a few days, with the key being the automation of execution by third-party data and smart contracts. However, this model depends on overseas data agencies (PCS, AIR), which poses data sovereignty and manipulation risks.

Tension between Licensed Compliance and Decentralization. Nayms chooses Bermuda regulation to gain licensing advantages (investor trust, legal protection) but sacrifices the fully decentralized 'permissionless' feature. This reflects the regulatory trend in risk tokenization.

Non-tradable Token Design. Unlike other risk tokenizations—where tokens have liquidity and appreciate or depreciate based on pool ratios—Nayms locks tokens entirely with the principal and does not allow circulation or trading during the insurance period. This design aligns better with the highly customized nature of catastrophe reinsurance. The locked holding period ensures that investors are 'true risk-takers' rather than 'speculators,' while avoiding liquidity exhaustion and insurance function failure caused by token sell-offs before a catastrophe. This design reflects different choices in the triangle of 'regulatory compliance - capital efficiency - essence of insurance' in risk tokenization.

4 Background of Risk Tokenization in China

China Completely Prohibits Risk Tokenization. Risk tokenization uses blockchain to convert traditional financial risks into programmable, divisible digital certificates for investors to gain risk exposure and liquidity. It poses risks: heightened risk contagion via high-frequency token trading, sovereign currency erosion from US dollar stablecoins squeezing digital renminbi, and a liability vacuum leaving investors with limited legal recourse for smart contract or oracle failures.

International cases show risk tokenization's efficiency, but its fully decentralized architecture conflicts with China's regulation. Its core technical strengths—atomic risk segmentation, smart contract automation, real-time settlement—provide references. Using Hainan's Typhoon Capricorn catastrophe risk as a case, this section explores absorbing these advantages while ensuring compliance to propose an innovative catastrophe risk diversification solution.

5 The Catastrophic Typhoon YAGI Disaster in Hainan in 2024 and the Exploration of Sinicization Solutions

5.1 Background and Data of the 2024 Hainan Typhoon Jiemo Disaster Case

The 11th super typhoon Yagi in 2024 was the strongest autumn typhoon to make landfall in China since the founding of the People's Republic of China, dealing a devastating blow to the tilapia aquaculture industry in Wenchang City.

The extreme systemic disasters also revealed the pain points of the traditional centralized insurance system. As of mid-October 2024, the insurance industry in Hainan Province had received over 100,000 claims, yet the estimated and paid-out amounts were only about RMB 4 billion. This data exposed three major pain points of the traditional catastrophe insurance system: first, the imbalance in coverage gaps, with insurance coverage only at 5%, and over 90% of losses being borne by the government and the public; second, the timeliness gap, where the survey environment under extreme disasters becomes paralyzed, resulting in a significant delay in the funding cycle, represented by T+N; third, the extremely high concentration of risk, where multiple types of insurance in the province are simultaneously affected, overburdening the balance sheets of local insurance institutions under systemic disasters, urgently requiring capital market intervention to smooth out risks.

5.2 Preliminary Exploration of the Tokenization Scheme for Compliance Risk with Chinese Characteristics

Risk voucher Layer: Tokenization Transformation of Catastrophe Bonds.

1.China's approach:

Catastrophe bonds are issued by insurance/reinsurance companies through SPVs, and the raised funds are deposited into an independent custodian account. If no catastrophe is triggered, investors receive coupon payments on schedule and recover their principal upon maturity; if the agreed catastrophe is triggered, the custodian funds are used to pay for the catastrophe losses. The triggering conditions are designed using parameterization (such as typhoon central wind force ≥17 and daily rainfall ≥250mm), eliminating moral hazard and loss adjustment costs in traditional insurance claims.

2.Main Advantages

Once investor funds are deposited into the SPV custodian account, they cannot be redeemed or withdrawn at will during the duration. This "lock-up" design serves a dual purpose: Firstly, it ensures the safety and sufficiency of insurance funds, maximizing risk coverage and preventing the depletion of the fund pool due to panic selling by investors before a catastrophic event;. Secondly, it avoids the liquidity speculation characteristics of tokens, aligning with China's regulatory requirements to "prevent finance from shifting from the real economy to the virtual economy".

Catastrophe bonds have already established a regulatory foundation in China, with clearly defined legal attributes, avoiding the qualitative dilemma of being labeled as "tokens". Therefore, the plan chooses catastrophe bonds as the "voucher" for investors' risk after paying the principal, which not only achieves the digital representation of risk exposure but also adheres to the compliance bottom line.

Currency Settlement Layer: Full-Process Integration of Digital RMB.

1. Actual challenges

International schemes commonly use US dollar stablecoins for fundraising and claims settlement, which seriously infringes on China's monetary sovereignty and violates foreign exchange control and anti-money laundering (AML) regulations.

2. China's approach. As shown in **Table 2.**

Table 2. Localization Plan for Currency Settlement Layer

Links	Specific mechanism
Fundraising side	Both domestic and overseas investors subscribed with digital yuan, and overseas institutions conducted compliant exchange through the Multilateral Central Bank Digital Currency Bridge (mBridge)
Hosting side	Funds are deposited into the Digital RMB Smart Contract Custody Account, with the central bank conducting full-process penetration monitoring
Trigger terminal	As an authoritative oracle, the meteorological bureau will upload typhoon data (such as the central wind force of Typhoon Yagi being ≥17) to the blockchain

Claims processing terminal	The smart contract automatically verifies the triggering conditions and instantly disburses digital yuan to the affected individuals or government disaster relief accounts in a targeted manner
Settlement terminal	T+0 real-time settlement, no exchange rate risk, no cross-border payment frictio

Technical Base Layer: Consortium Chain and Pervasive Supervision.

1. Actual challenges:

Chinese law clearly stipulates that no organization is allowed to conduct ICO and virtual currency transactions within China.

2. China's approach. As shown in **Table 3.**

Table 3. Localization Compliance Design of the Technical Base Layer in China

Dimension	International scheme (prohibited)	Chinese solution (compliant)
Definition of terms	Token	Digital catastrophe bonds or asset equity certificates are listed on the blockchain
Infrastructure	Public chains such as Ethereum	Case: Hainan Free Trade Port Exclusive Alliance Chain (regulated by the state)
Regulatory node	nothing	The National Financial Regulatory Administration, the People's Bank of China, and the China Meteorological Administration serve as regulatory nodes on the consortium blockchain
Data sovereignty	Commercial decentralized oracle machine	The meteorological bureau serves as the sole authoritative oracle node
Cross-border data transfer	Public on the chain	Privacy: Foreign investors only see risk ratings, not sensitive geographic data

Investor Protection: Strict Access and Risk Coverage.

1.Actual challenges

Catastrophe bonds are high-risk, high-return derivatives. If they are made available to the general public, they will pose significant social risks related to rights protection.

2.China's approach. As shown in **Table 4.**

Table 4. Compliance Design for Investor Protection in China

Mechanism	Specific content
Whitelist access	The smart contract is embedded with an identity authentication mechanism, allowing only institutional investors such as reinsurance companies, hedge funds, and large pension funds to subscribe. Retail investors are strictly prohibited from participating

Mechanism	Specific content
Legal relief	Within the domestic jurisdiction, investors' rights and interests are protected by the Insurance Law of the People's Republic of China and the Trust Law of the People's Republic of China
Technical backstop	Within the domestic jurisdiction, investors' rights and interests are protected by the Insurance Law of the People's Republic of China and the Trust Law of the People's Republic of China

SPV Architecture: Hainan-Hong Kong Interconnection Model.

1. Actual challenges

The Company Law and Bankruptcy Law of the People's Republic of China in Chinese Mainland provide insufficient support for the establishment of "tax-exempt, fully bankruptcy-remote" entity-type Special Purpose Vehicles (SPV) specifically designed for risk transfer. Currently, most catastrophe bonds are issued in Hong Kong as a detour.

2. China's approach:

The underlying assets are located in Hainan, where the local property insurance company packages the risk exposure of Typhoon Yagi and entrusts it to a trust company (leveraging the bankruptcy remoteness feature of China's "Trust Law of the People's Republic of China") as the domestic manager in Hainan Free Trade Port. The token issuance takes place in Hong Kong, where the domestic trust beneficiary rights are mapped to a regulated and compliant trading platform in Hong Kong through cross-chain technology. Leveraging Hong Kong's existing tax exemption policy for catastrophe bonds and the advantages of the common law system, digital tokens are issued to global capital.

The Legal Validity of Smart Contracts and the circuit Breaker Mechanism.

1. Actual challenges

The automatic execution of blockchain is irreversible, which presents flaws under the Civil Code of the People's Republic of China. In extreme cases, such as typhoons destroying meteorological equipment and resulting in data loss, pure code logic may mistakenly reject claims, leading to significant legal disputes.

2.China's approach:

The core principle is to prioritize code execution, with manual intervention reserved. As shown in **Table 5.**

Table 5. Localized Compliance Design in the Smart Contract Layer

Mechanism	Function	Applicable situations
Multi-signature intervention	Major operations can only be executed with the joint signatures of multiple supervision nodes	Routine supervision to prevent single-point risks
Smart contract circuit breaker	The regulatory authority can suspend the execution of the contract and initiate man-	Emergency situations such as data anomalies and sys-

Mechanism	Function	Applicable situations
	ual review	tem attacks
Off-chain arbitration clause	The smart contract incorporates an arbitration agreement, stipulating that disputes shall be submitted to domestic arbitration institutions	Legal disputes, safeguarding investors' right to relief
Supplementary triggering mechanism	When the primary data source is missing, the backup data source is enabled or manual evaluation is conducted	Extreme disasters cause equipment damage

6 Simulation Plan for Tokenization Risk Diversification of Tilapia Aquaculture in Wenchang City, a Seriously Affected Area by Typhoon Haishen in 2024

6.1 Simulation Model

Core Parameter Group.

1. Parameter of trigger condition

To avoid the basis risk brought by a single wind speed measurement and grading (such as when the wind speed reaches the trigger condition parameters but it is not raining, resulting in no overtopping of the dam and essentially no fish escaping), this simulation model will introduce a dual-parameter fusion index of wind speed and precipitation. As shown in **Table 6**.

Table 6. Trigger Parameter Setting Table

Oracle data source	The China Meteorological Administration's central API interface is directly connected to the consortium blockchain
Spatial parameters (Drid)	The grid meteorological station located within the jurisdiction of Wenchang City (19°20′N~20°10′N, 110°41′E~111°15′E)
Storm parameter (W_max)	During the typhoon impact period (24 hours before and after landfall), the maximum wind speed recorded within the grid (unit: m/s)
Rainfall parameter (R_24h)	The cumulative rainfall (unit: mm) of the grid within 24 hours before and after the typhoon center passes through

2.Parameter of loss assessment

In this section, the model will rely on the meteorological damage index for tiered compensation, setting the compensation ratio according to the triggering conditions. Different triggering ratios will be generated when the weighted values fall within different ranges. As shown in **Table 7**.

Table 7. Loss Assessment Parameter Setting Table

Disaster damage index (Index)	The destructive force value generated by weighting wind speed and rainfall	\
Compensation ratio (Ratio)	Index < 100	Trigger 0% (normal weather, no compensation)
\	100 ≤ Index < 130	Trigger 30% (Slight equipment damage, partial fish death due to power outage)
\	130 ≤ Index < 160	Trigger 60% (large-scale dam overflow, fish death and escape)
\	Index ≥ 160	Trigger 100% (devastating blow, full compensation)

When the wind speed reaches 40m/s (Grade 13-14), and there is a heavy rainfall of 200mm, the Index is approximately 100. The actual impact is that ordinary rural power grid wires begin to break, some simple fish ponds are damaged, and traffic is somewhat obstructed but not completely blocked. Farmers can use diesel generators to supplement for a period of time, and the losses incurred are not so severe as to cause total crop failure. When the wind speed reaches 50m/s (Grade 15), and there is a rainstorm with 300mm of rainfall, the Index is approximately 130. The actual impact is that the main power grid is severely damaged, a large number of fish ponds are flooded, and farmers' diesel generators struggle to support longer periods of time, leading to a full outbreak of secondary disaster chains. The Index line at 160 is a true reflection of the Typhoon Yagi in 2024, with wind speeds exceeding 60m/s (a super typhoon above Grade 17) and extremely heavy rainfall. The actual impact is devastating and irresistible. At this time, no human effort can recover the losses on the farm, and it is necessary to invest 100% in releasing the lock-up pool foe fundamental post-disaster reconstruction.

3.Parameter of fund pool

Fund medium: Utilize digital yuan e-CNY throughout the entire cycle.

Total Value Locked (TVL): 50 million yuan for the special risk coverage pool of the tilapia industry in Wenchang City.

Setting basis: Wenchang City is a renowned breeding and cultivation base for tilapia, covering all agricultural sectors across Hainan Island, with a scale of at least several billion yuan. However, as this is only a preliminary exploration of tokenization for a single industry + a single city/county in a blockchain sandbox, 50 million yuan is a relatively appropriate pilot scale.

Fund source (investor subscription): Global compliant institutional investors (such as reinsurance funds and large asset management institutions) access the central bank's multilateral currency bridge through a compliant overseas institutional investor channel, utilizing a consortium chain smart contract.

Premium contributor: 70% funded by Wenchang Ruoshi City. 0% borne by individuals, paid to the smart contract, with a set premium rate of p=5% (i.e.,2.5 million RMB as the premium).

Setting basis: In the real society of China, purely commercial agricultural catastrophe insurance is simply unaffordable for farmers. According to the regulations of the Ministry of Finance and the National Financial Regulatory Administration, insurance premiums are usually subsidized by the central government, provincial governments, and municipal and county governments at various levels. The subsidy ratio is usually between 60% and 80%. Therefore, setting the ratio of 70% funded by the government and 30% funded by individuals or cooperatives aligns with China's reform direction, which leverages fiscal funds to stimulate the capital market. For the setting of p, catastrophes such as RMS are simply unaffordable. The expected loss rate of typhoons in the south is usually around 2% to 3%. The capital invested in catastrophe bonds not only needs to cover losses but also obtain returns. The total annualized return (APY) is around 7.5%, which is more commercially attractive than the yield of most compliant decentralized finance (DeFi) coin collateral.

Risk-free interest rate (Rf): By calling the API in the smart contract backend, idle e-CNY can be automatically used to purchase special bonds issued by the local government of Hainan Province, earning a risk-free annualized interest rate of approximately 2.5%.

Setting basis: Digital RMB belongs to the M0 level and is not urgently needed. In order to provide foreign investors with compliant returns, the smart contract must be anchored at the underlying level with Chinese treasury bonds or special bonds issued at the provincial level in Hainan Province. In 2024, the yield of China's 1-year/3-year treasury bonds hovered around 2% to 3%, so setting a risk-free interest rate of 2.5% is closer to the real macroeconomic situation. Time parameters (effective/due/settlement).

Effective Date (T_start): January 1, 2024, 00:00 (warehouse construction to be completed before the typhoon season).

Expiration time (T_end): 23:59 on December 31, 2024 (covering the entire autumn typhoon high-incidence period).

Settlement delay period (T_settle): T+0 - that is, after the oracle data confirms that the trigger parameters are met, the smart contract automatically executes e-CNY transfer within a very short second-level time, without manual intervention for review.

Parameter of supervision and risk control.

Regulatory node: The Digital Currency Research Institute of the People's Bank of China monitors the flow of funds to prevent money laundering, while the Hainan Regulatory Authority of the National Financial Regulatory Administration conducts compliance audits.

Whitelist access mechanism: The payee for claims settlement must be the exclusive digital RMB corporate wallet of a large tilapia farming household or cooperative that has completed real-name authentication (to prevent funds from being misappropriated)

Fusing and manual intervention mechanism: In extreme situations, such as when a Category 17 typhoon destroys all meteorological radars in Wenchang, resulting in data loss, the smart contract will immediately be suspended and handed over to official entities such as the meteorological bureau and regulatory authority for real-time off-chain multi-signature emergency rescue. The actual data will be overwritten with satellite cloud imagery.

Calculation Formula.

1.Disaster damage index formula

$$Index = (\alpha \times W\_\max) + (\beta \times R\_24h) \tag{1}$$

α represents the weight coefficient for wind speed, while β denotes the weight coefficient for rainfall. The primary reason why tilapia aquaculture is severely impacted by typhoons is due to widespread power outages caused by the storms, leading to oxygen depletion. Given the extremely high density of tilapia in the aquaculture ponds, the sudden cessation of aeration equipment can cause hypoxia and mass fish deaths within a short period of time. Additionally, typhoons can disrupt transportation, preventing the delivery of rescue equipment such as generators. Therefore, α is highly positively correlated with tilapia mortality, and is set at 2.0. Rainfall can lead to fish escaping through breaches in the dam, but measures such as raising the aquaculture nets can relatively control the losses. It is not a fatal factor affecting tilapia aquaculture, hence β is set at 0.1. Setting α=2.0 amplifies the influence of wind, while β=0.1 diminishes the impact of precipitation, effectively fitting the real agricultural disaster chain and reducing basis risk.

2.Intelligent contract automatic claim payment formula

$$Payout = TVL \times Ratio(Index) \tag{2}$$

The smart contract will unlock and allocate the digital yuan principal in the fund pool to the disaster area in proportion according to the four preset trigger ratios

3.Formula for distributing compensation to affected farmers or cooperatives

$$Comp\_farmer = Payout \times \frac{Area\_i}{\sum Area\_total} \tag{3}$$

Area_i represents the acreage of aquaculture water surface that is confirmed on the blockchain through drone remote sensing when the ith user applies for insurance. The disaster relief funds received by the insured users in the disaster area are equal to the total payout, divided according to the proportion of the confirmed area to the total area.

4.Settlement of principal and earnings for on-chain investors

Assuming that a typhoon disaster occurs on the d-th day of the 365 days in 2024

$$Return = TVL \times (1 - \mathrm{Ratio}) + TVL \times \left[\frac{\mathrm{p} + R\mathrm{f}}{365}\right] \times \mathrm{d} \tag{4}$$

TVL represents the total locked-up value, Ratio denotes the payout ratio determined based on the triggering conditions, p stands for the premium rate, and Rf signifies the risk-free interest rate.

Simulation Deduction and its Results.

1. Background event

On September 6, 2024, Typhoon Jangmi made landfall in Wengtian Town, Wenchang

City, Hainan Province, with a time elapsed of d=249 days since the effective date.

2.On-chain oracle data

The meteorological bureau node broadcasts the final extreme value data to the smart contract:

Maximum wind speed in Wenchang: $W\_\max = 62.0m/s$

24-hour rainfall in Wenchang: $R\_24h = 450mm$

3.Automatic calculation of disaster damage index

$$Index = (2.0 \times 62.0) + (0.1 \times 450) = 169$$

4.Determination of claim settlement ratio and fund allocation

Due to $Index = 169 \geq 160$,the fourth highest threshold was triggered, so we have $Radio = 100\%$

5.Execution result

The smart contract categorized the impact of Typhoon Jangmi on tilapia farming in Wenchang City as a devastating blow. On September 6th, all 50 million digital yuan in the lock-up pool TVL were unfrozen and directly transferred out. As there was no need for on-site counting, these 50 million yuan were still accurately transferred into the corporate digital wallets of individual tilapia farmers or cooperatives at a second-level speed (T+0 compensation) despite the internet and power outages, as well as blocked roads.

6.Settlement of investors' principal and earnings

$$\mathrm{Re}\,turn = 5000 \times (1 - 100\%) + \frac{5000(5\% + 2.5\%)}{365 \times 249} = 255$$

That is, the investor lost all of the 50 million yuan principal and only received 2.55 million yuan in interest earned before the disaster. The capital bore the tail risk transfer for the tilapia aquaculture industry in Wenchang City.

6.2 Simulation Model'S Conclusion

The simulation model for Wenchang's tilapia tokenized catastrophe bond resolves the low efficiency and high cost of loss determination in traditional insurance, as well as the impracticality of manual fish counting for agricultural claims during catastrophes. With a premium of 2.5 million RMB, the Wenchang municipal government and policyholders successfully transferred 50 million RMB of absolute risk to the capital market via tokenization, achieving qualitative improvement in capital efficiency compared to traditional fiscal disaster relief. The entire simulation involves no token speculation; instead, based on digital yuan and a government alliance chain, typhoon risk is converted into a financial lifeline through rigorous encryption algorithms, accurately supporting affected people.

7 Summary and Outlook

Risk tokenization brings new potential for global catastrophe risk diversification but suffers from legal ambiguity, insufficient investor protection and monetary sovereignty risks, with pure decentralization failing to balance efficiency, security and compliance. The Chinese solution proposed reconstructs the model under the high-level socialist market economy by adopting digital RMB, regulatory consortium blockchains and locked catastrophe bond vouchers, absorbing technical advantages while upholding financial sovereignty and achieving “functional isomorphism and formal compliance”. Going forward, with digital RMB internationalization and mBridge progress, the scheme can link domestic catastrophe assets with global compliant capital. Based on Hainan Free Trade Port, a cross-regional regulatory sandbox for tokenized catastrophe funds can be built, turning fintech into key infrastructure to improve national disaster resilience and drive high-quality real-economy development.

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