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Blockchain-Enabled Mortgage Markets: Tokenization, Alternative Asset Classes, and Financial Stability A Macroeconomic Framework for Distressed Asset Resolution

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Abstract

This paper develops a macroeconomic framework for blockchainenabled mortgage markets in which distressed assets can be tokenised and converted into tradable alternative investment instruments, facilitating rapid resolution of bank non-performing loans (NPLs) and restoring credit flow during financial crises. We construct a dynamic stochastic general equilibrium (DSGE) model with heterogeneous banks, mortgage portfolios subject to stochastic default risk, and a blockchain-based secondary market for mortgage-backed tokens (MBTs) accessible to alternative investors. The key innovation is a dual-channel resolution mechanism: (i) traditional foreclosure with deadweight losses; and (ii) blockchain tokenisation enabling fractional ownership transfer to specialised distressed-asset investors at transparent marketclearing prices. Smart contracts automate collateral verification, payment-waterfall distribution, and real-time valuation, reducing information asymmetries and transaction costs by 60–75% relative to conventional securitisation. Our calibrated model generates four main results. First, blockchain tokenisation accelerates NPL resolution by 18–24 months, reducing banks' distressed-asset overhang from 8.2% to 2.4% of total assets during crisis periods. Second, the availability of alternative investment channels increases equilibrium credit supply by 12–18%, dampening credit crunches. Third, monetarypolicy transmission improves: interest-rate pass-through to mortgage rates rises from 0.42 to 0.68 when blockchain infrastructure enables continuous price discovery. Fourth, systemic risk declines: the probability of a financial crisis falls by 35% owing to enhanced balance-sheet repair mechanisms. We identify an optimal regulatory design: permissioned blockchains with qualified-investor requirements, automaticstay provisions during restructuring, and central-bank discountwindow access for MBT-collateralised lending. Quantitative analysis using 2008 US financial-crisis counterfactuals shows that blockchain resolution could have reduced output losses by $1.2 trillion (8.5% of GDP) through faster deleveraging. The framework offers policy guidance for central banks and regulators seeking to harness distributed-ledger technology for financial stability2 while managing risks of market fragmentation and regulatory arbitrage.

1. Introduction

Financial crises are fundamentally crises of impaired bank balance sheets. When mortgage default rates surge, banks face a toxic combination: rising non-performing loans (NPLs) consume capital, regulatory requirements force deleveraging, and fire sales of collateral further depress asset prices. The resulting credit crunch amplifies the real economic contraction. The 2008 Global Financial Crisis exemplified this dynamic: US banks held $1.4 trillion in distressed mortgages at their peak; credit markets froze; and GDP fell 4.3% in 2009. Traditional resolution mechanisms are notoriously slow and costly. Foreclosure takes 18–36 months in the United States and 4–7 years in Europe. During this limbo, houses deteriorate, legal costs mount, and banks' balance sheets remain impaired.

Asset sales to specialised distressed investors do occur, but face severe frictions: opaque pricing, high due-diligence costs, and thin markets with few buyers generate deadweight losses of 30–50% of recoverable value. This paper proposes and analyses a transformative alternative: *blockchain-enabled mortgage tokenisation*, which converts distressed loans into tradable digital securities accessible to diverse alternative investors. Smart contracts on distributed ledgers automate collateral verification, enforce payment waterfalls, and enable fractional ownership at granular levels ($1,000 minimum investment versus $10 million for conventional MBS tranches). Continuous price discovery via token trading provides real-time mark-to-market valuation. Crucially, this creates a *liquid secondary market* for bad assets that did not previously exist.

1.1. The Blockchain Resolution Mechanism

Consider a bank holding $100 million in NPLs secured by residential properties. The traditional menu of options is limited and costly:

- ➢ **Option 1 — Foreclosure.** Costs $50,000 per property, takes 24 months, and recovers 60% of collateral value; the bank realises approximately $45 million net recovery over two years.
- ➢ **Option 2 — Bulk Sale.** Sell the portfolio to a distressed-debt fund at fifty cents on the dollar, yielding $50 million immediately but at an extreme discount.
- ➢ **Option 3 — Blockchain Tokenisation (Proposed).** The resolution process proceeds through the following stages:

- *Tokenisation*. Each mortgage is converted into digital tokens representing fractional claims (e.g., 1 token = $1,000 principal).
- *Smart-Contract Terms*. Embedded rights to foreclosure proceeds and automated distribution of recoveries are encoded on-chain.
- *Listing*. Tokens are traded on a blockchain exchange accessible to retail investors, family offices, hedge funds, and REITs.
- *Price Discovery*. Continuous trading reveals the market-clearing price (e.g., seventy-five cents on the dollar).
- *Bank Exit*. Tokens are sold progressively, recovering $75 million over six months versus twenty-four months.
- *Investor Entry*. Alternative investors acquire tokens and manage the recovery process (restructuring, rental conversion, or resale).
- The key advantages of the proposed mechanism are: *speed* (six months versus twenty-four); *higher recovery* (75% versus 50–60%); *liquidity* (continuous trading versus illiquid bilateral negotiations); *transparency* (blockchain immutability and smart-contract automation); and access (a broader investor base driving competitive pricing).

1.2. Macroeconomic Implications

Faster NPL resolution has profound macroeconomic consequences.

- **Credit-Supply Restoration.** Banks with cleaner balance sheets resume lending more readily. Our model demonstrates 12–18% higher credit supply during crisis periods under blockchain resolution.
- **Reduced Fire Sales.** Orderly token sales prevent price spirals. House prices decline 15–20% less during crises.
- **Alternative Investment Channel.** Diverting bad assets to specialised investors with expertise in restructuring improves allocative efficiency.
- **Monetary Policy Effectiveness.** With functioning secondary markets, interestrate transmission improves: pass-through rises from 0.42 to 0.68.
- **Systemic Risk Reduction.** Faster deleveraging prevents contagion; crisis probability falls by 35%.

1.3. Research Questions

This paper addresses the following questions:

- *Theoretical mechanism*. How does blockchain tokenisation affect bank lending, asset prices, and macroeconomic stability?
- *Optimal design*. What regulatory framework maximises social welfare? Permissioned versus permissionless? What investor qualifications should be required?
- *Quantitative magnitude*. How large are the welfare gains? Can blockchain resolution prevent financial crises?
- *Implementation challenges*. What risks arise from market fragmentation, regulatory arbitrage, and cyber security? How should they be mitigated?
- *Policy implications*. Should central banks accept MBTs as collateral? What role should deposit insurance play?

1.4. Preview of Results

We build a DSGE model incorporating a banking sector, mortgage markets, and a blockchain-enabled secondary market for distressed assets. The key findings are as follows.

- **Result 1 — Accelerated Resolution.** Blockchain tokenisation reduces the average NPL holding period from 28 months to 7 months, a 75% reduction, freeing $82 billion in bank capital (calibrated to 2008 crisis scale).
- **Result 2 — Credit Expansion.** Enhanced lending capacity increases equilibrium credit by 15%, raising GDP by 2.4% in crisis periods relative to the no-blockchain baseline.
- **Result 3 — Asset-Price Stabilisation.** A broader investor base for distressed properties reduces house-price volatility by 22%, and fire-sale externalities diminish significantly.
- **Result 4 — Welfare Gains.** The consumption-equivalent welfare improvement is 3.2% during financial crises and 0.8% on average over a ten-year horizon including one crisis episode.
- **Result 5 — Optimal Regulation.** A permissioned blockchain with accredited investor requirements dominates an open system. Central-bank acceptance of MBTs as collateral (with appropriate haircuts) enhances stability.

1.5. Contribution to the Literature

This research bridges three distinct literatures.

Financial Frictions and Business Cycles. Bernanke and Gertler pioneered the analysis of credit-market imperfections that amplify shocks. modelled credit cycles with collateral constraints [1]. integrated banking crises into DSGE frameworks [2]. We extend this tradition by adding endogenous resolution technology:

blockchain reduces frictions in distressed-asset markets, thereby dampening the financial accelerator [3].

Mortgage Markets and Housing Finance. documented how mortgage credit expansion fuelled the housing boom [4]. Keys showed that securitisation reduced screening incentives. Piskorski et al [5,6]. analysed modification frictions. Our contribution is to model blockchain as a new securitisation technology with fundamentally different properties — transparency, automation, and granular fractional ownership.

Blockchain and Distributed Ledger Technology in Finance. The computerscience literature explores technical aspects [7]. Cong and He analyse corporate governance implications [8]. Chod and Lyandres study supply-chain finance [9]. We provide the first macroeconomic general-equilibrium analysis of blockchain mortgage markets with rigorous welfare analysis.

1.6. Paper Organisation

Section 2 provides institutional background on blockchain mortgage markets. Section 3 develops the theoretical model. Section 4 calibrates the parameters. Section 5 presents quantitative results. Section 6 derives optimal regulatory design. Section 7 discusses policy implications. Section 8 concludes. Mathematical derivations are collected in Appendix A and the computational algorithm is described in Appendix B.

2. Institutional Background: Blockchain Mortgage Markets

2.1. Traditional Mortgage Securitisation

2.1.1. The Process

The conventional mortgage-backed securities (MBS) pipeline operates through five sequential stages: (i) banks originate mortgages; (ii) pools are sold to a Special Purpose Vehicle (SPV); (iii) the SPV issues tranches (AAA, AA, BBB, and equity) to capital-market investors; (iv) credit rating agencies assess the risk of each tranche; and (v) investors receive cash flows from underlying mortgage payments according to a prescribed waterfall.

2.1.2. Frictions and Failures

The 2008 crisis revealed severe structural deficiencies in this pipeline. Opacity prevented investors from assessing underlying mortgage quality, producing excessive reliance on ratings that were themselves flawed. Agency problems emerged because originators bore no residual risk after sale — the so-called originate-to-distribute model. MBS markets froze during the crisis, eliminating price discovery precisely when it was most needed. Complexity in CDO and CDO-squared structures further obscured aggregate risk. Servicers faced misaligned incentives that inhibited loan modifications. For distressed mortgages, these problems were amplified. No active secondary market existed; bulk sales occurred at 30–50 cents on the dollar. Legal complexity prevented unbundling, and information asymmetry — buyers' fear of adverse selection — depressed prices further.

2.2. Blockchain Solution Architecture

2.2.1. Technical Components

- **Distributed Ledger.** An immutable, consensus-validated record captures: mortgage origination terms; payment history; collateral characteristics (property address, valuation, and condition reports); modification history; and the complete ownership chain of token holders. The consensus mechanism ensures data integrity without a central authority.
- **Smart Contracts.** Self-executing code governs all contractual obligations: payment distribution through an automated waterfall (interest → principal → fees); automatic NPL classification after 90 days of delinquency; token-holder voting rights on foreclosure versus modification; and pro-rata distribution of collateral-sale proceeds.

A representative smart-contract structure is shown below:

```
contract MortgageToken {
    address public property;
    uint256 public principal;
    uint256 public interestRate;
    address[] public tokenHolders;

    function distributePayment(uint256 amount) public {
        // Waterfall logic
        uint256 interestDue = calculateInterest();
        if (amount >= interestDue) {
            payInterest(interestDue);
            payPrincipal(amount - interestDue);
        } else {
            payInterest(amount);
        }
    }

    function declareDefault() public {
        require(daysPastDue >= 90);
        initiateForeclosure();
    }
}
```

Listing 1: Solidity pseudocode for a mortgage-token smart contract

- **Tokenisation.** Each mortgage is divided into fungible ERC-20 tokens. One token represents a $1,000 principal claim. Tokens trade on decentralised exchanges (DEXs) and may be acquired in fractional amounts, enabling retail-investor participation that was previously excluded by the $10 million minimum required for a conventional MBS tranche.
- **Oracle Integration.** Real-world data is fed to the blockchain via cryptographically signed oracle feeds: house-price indices (Zillow, CoreLogic); reference interest rates (SOFR); credit scores (FICO); and property condition data (IoT sensors and inspection reports). Smart contracts verify data authenticity before executing on-chain logic.

2.2.2. Workflow for Distressed Mortgages

The full lifecycle of a blockchain-resolved distressed mortgage unfolds across five phases.

- **Phase 1 — Origination and Tokenisation.** At closing, the bank originates the mortgage and simultaneously creates tokens with embedded metadata (LTV, FICO score, property details). Tokens are initially retained on the bank's balance sheet.
- **Phase 2 — Performance Period.** Borrower payments trigger the smart contract to distribute proceeds to token holders in real time. An immutable audit trail is maintained on-chain, enabling continuous portfolio monitoring.
- **Phase 3 — Default and Secondary Listing.** After three missed payments the contract automatically classifies the loan as an NPL. The bank then decides whether to retain and resolve the loan or to list tokens on the secondary market for price discovery.
- **Phase 4 — Alternative Investor Acquisition.** Distressed-debt funds, REITs, hedge funds, and family offices compete to acquire tokens at a market-clearing price — illustratively, seventy cents on the dollar. The bank exits its position; investors take ownership.
- **Phase 5 — Recovery Process.** New token holders manage the workout through loan modification, foreclosure and property sale, or conversion to rental housing. All proceeds are distributed automatically via smart contract; all parties observe recovery progress in real time.

2.3. Comparison to the Traditional Process

Table 1 summarises the key dimensions across which the blockchain mechanism differs from the traditional process.

2.4. Empirical Evidence

2.4.1. Pilot Programmes

Several blockchain mortgage initiatives have generated encouraging early evidence.

Figure Technologies (US). Figure Technologies originated $4 billion in mortgages on the Provenance blockchain between 2019 and 2023. Average processing time fell to 5 days from 30–45 days under the traditional process, while operational expenses declined by 60%. The resultant default rate of 1.2% was comparable to traditional benchmarks [10].

Dimension	Traditional	Blockchain
Timeline	24–36 months	6–12 months
Transaction costs	15–25% of recovery	3–5% (smart-contract fees)
Information	Opaque; intensive due diligence	Transparent; on-chain history
Minimum investment	$10–50 million (bulk sale)	$1,000 (fractional tokens)
Investor base	5–10 specialised funds	Hundreds of diverse in- vestors
Price discovery	Bilateral negotiation	Continuous market trading
Operations	Manual servicing	Automated smart contracts
Legal complexity	High (assignment proce-dures)	Low (atomic token transfer)
Recovery rate	50–60%	70–80% (broader competition)

Table 1: Blockchain Versus Traditional Distressed Mortgage Resolution

Propy (International). Propy's Ethereum-based real estate transaction platform completed over 1,000 property transfers across 20 countries, reducing transaction costs by 40% [11].

JPMorgan Onyx (Institutional). JPMorgan's permissioned blockchain for repo markets processed over $1 trillion in transactions between 2020 and 2024, reducing settlement time from T+2 to real-time [12].

2.4.2. European NPL Market Data

The European Banking Authority reports €506 billion in NPLs on EU bank balance sheets as of 2022. Blockchain pilots have delivered material improvements. UniCredit's blockchain NPL platform in Italy reduced sale timelines from 18 months to 4 months. The National Bank of Greece tokenised €200 million in distressed mortgages, achieving a 68% recovery rate versus 52% for traditional sales. BBVA's blockchain mortgage platform in Spain delivered a 40% cost reduction [13].

2.5. Regulatory Landscape

2.5.1. United States

The US regulatory environment is fragmented but evolving. The SEC classifies tokens as securities where they satisfy the Howey test, requiring registration or an applicable exemption. The OCC granted approval for national banks to hold crypto assets in 2021. The FDIC is currently studying deposit-insurance implications for blockchain-based banks. At the state level, Wyoming and Texas have created specialpurpose depository institutions (SPDIs) to accommodate crypto-native business models.

2.5.2. Europe

Europe has adopted a more comprehensive approach. The Markets in Crypto- Assets (MiCA) regulation, effective from 2024, establishes a unified framework. The EU's DLT Pilot Regime creates a sandbox for tokenised-securities trading with targeted exemptions. EBA Guidelines specify the prudential treatment of cryptoasset exposures.

2.5.3. Outstanding Challenges

Several regulatory challenges remain unresolved across jurisdictions: the legal enforceability of smart contracts; cross-border coordination on governing-law questions; investor-protection standards for retail participants; AML/KYC compliance for pseudonymous wallet addresses; and cyber-security vulnerabilities including smartcontract bugs and 51% attacks.

3. Theoretical Model

We develop a DSGE model with heterogeneous banks, mortgage markets, and a blockchain-enabled secondary market for distressed assets.

3.1. Environment

Time. Discrete, infinite horizon $t = 0,1,2,...$

Agents. The economy is populated by four types of private agents — households (homeowners and savers), banks (mortgage lenders), alternative investors (distressedasset specialists), and non-financial firms — together with a central bank.

Assets. The asset menu comprises: houses H; performing mortgages M; nonperforming loans N (more than 90 days delinquent); mortgage-backed tokens T (blockchain-tokenised NPLs); deposits D; and government bonds B.

3.2. Households

3.2.1. Preferences

The representative household maximises expected lifetime utility:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{\left(C_t^{\gamma} H_t^{1-\gamma}\right)^{1-\sigma}}{1-\sigma} - \chi \frac{N_t^{1+\eta}}{1+\eta} \right], \tag{1}$$

where C_t is consumption, H_t is housing services, N_t is labour supply, $\gamma \in (0,1)$ is the consumption share in the composite good, $\sigma > 0$ is the coefficient of relative risk aversion, and $\eta > 0$ is the inverse Frisch elasticity.

3.2.2. Housing Acquisition

Households purchase houses using mortgage financing:

$$P_t^H H_{t+1} = M_t + E_t, \tag{2}$$

where P_t^H is the house price, M_t is the mortgage amount, and E_t is equity (the down payment). A loan-to-value constraint binds:

$$M_t \leq \theta P_t^H H_{t+1}, \tag{3}$$

where $\theta \in (0,1)$ is the maximum LTV ratio.

3.2.3. Mortgage Default Decision

$\lambda^{\text{trad}} P_t^H$

Households face idiosyncratic income shocks $\xi_t \sim F(\xi)$. When the shock is sufficiently adverse, the household defaults. The default threshold is:

$$\xi_t^* = \frac{(1 + r_t^M) M_{t-1}}{W_t N_t}, \tag{4}$$

where r_t^M is the mortgage rate and W_t is the wage. Upon default, the household loses the house to foreclosure and the bank acquires the property, subsequently selling it at the fire-sale price λP_t^H (fire-sale discount $1 - \lambda$). The household additionally suffers a utility cost κ capturing stigma, relocation costs, and credit-score damage. The aggregate default rate is:

$$\delta_t = F(\xi_t^*) = \Pr(\xi_t < \xi_t^*). \tag{5}$$

3.3. Banks

3.3.1. Balance Sheet

Bank j holds assets comprising performing mortgages $M_{j,t}$, NPLs $N_{j,t}$, and government bonds $B_{j,t}$, funded by deposits $D_{j,t}$ and equity $E_{j,t}$:

$$M_{j,t} + N_{j,t} + B_{j,t} = D_{j,t} + E_{j,t}. \tag{6}$$

3.3.2. NPL Dynamics

Performing mortgages migrate to NPL status at the endogenous default rate:

$$N_{j,t+1} = (1 - \rho) N_{j,t} + \delta_t M_{j,t}, \tag{7}$$

where ρ is the NPL resolution rate, which is endogenous and depends on the resolution technology deployed.

Traditional Resolution. Foreclosure requires T^{trad} periods with recovery rate λ^{trad}.

Blockchain Resolution. Banks may tokenise NPLs and sell the resulting MBTs to alternative investors, with the resolution dynamics characterised below.

3.3.3. Tokenisation Decision

Bank j chooses the fraction $\tau_{j,t} \in [0,1]$ of its NPL stock to tokenise. Tokenised NPLs are converted to MBTs at cost φ^{token} per dollar of face value and listed on the blockchain exchange, where they sell to alternative investors at the equilibrium price P_t^{MBT}. The bank receives $P_t^{\text{MBT}}(1 - \varphi^{\text{token}})\tau_{j,t} N_{j,t}$ immediately.

Non-tokenised NPLs are resolved via traditional foreclosure, yielding present value $\lambda^{\text{trad}} P_t^H / (1 + r) T^{\text{trad}}$ per unit.

The optimal tokenisation decision follows a threshold rule:

$$\tau_{j,t}^* = \begin{cases} 1 & \text{if } P_t^{\text{MBT}}(1 - \varphi^{\text{token}}) > \dfrac{\lambda^{\text{trad}} P_t^H}{(1+r)^{T^{\text{trad}}}} \\ 0 & \text{otherwise.} \end{cases} \tag{8}$$

In equilibrium, the marginal bank is indifferent between the two channels:

$$P_t^{\mathrm{MBT}} = \frac{1}{1-\varphi^{\mathrm{token}}} \cdot \frac{\lambda^{\mathrm{trad}} P_t^H}{(1+r)^{T^{\mathrm{trad}}}}. \tag{9}$$

3.3.4. Capital Requirement

The regulatory capital constraint requires:

$$E_{j,t} \geq \kappa^M M_{j,t} + \kappa^N N_{j,t}, \tag{10}$$

where κ^M is the risk weight on performing mortgages and $\kappa^N > \kappa^M$ is the higher risk weight on NPLs. When the constraint binds, the bank may raise equity at cost Ψ, reduce lending (generating a credit crunch), or sell NPLs via tokenisation.

3.3.5. Bank Optimisation

Bank *j* maximises shareholder value:

$$V_{j,t} = \max_{M_{j,t+1},\,\tau_{j,t}} \mathbb{E}_t \sum_{s=0}^{\infty} \Lambda_{t,t+s} \Pi_{j,t+s}, \tag{11}$$

where $\Lambda_{t,t+s}$ is the stochastic discount factor and profits are:

$$\Pi_{j,t} = r_t^M M_{j,t} - r_t^D D_{j,t} + P_t^{\mathrm{MBT}}(1-\varphi^{\mathrm{token}})\tau_{j,t} N_{j,t} - \Psi \Delta E_{j,t}. \tag{12}$$

The first-order condition for lending is (see Appendix A):

$$r_t^M - r_t^D = \mu_t \kappa^M + \beta\, \mathbb{E}_t \Lambda_{t,t+1} \delta_{t+1} \left[\kappa^N - P_{t+1}^{\mathrm{MBT}}(1-\varphi^{\mathrm{token}})\right], \tag{13}$$

where µt is the Lagrange multiplier on the capital constraint. The mortgage-rate spread reflects: (i) the capital-requirement cost $\mu_t \kappa^M$; and (ii) expected NPL costs net of tokenisation recovery. A higher MBT price lowers the spread, stimulating lending.

3.4. Alternative Investors

3.4.1. Characteristics

Alternative investors possess expertise in distressed-asset management (restructuring, foreclosure, and property management), enabling them to achieve a superior recovery rate $\lambda^{\mathrm{alt}} > \lambda^{\mathrm{trad}}$ and a shorter resolution horizon $T^{\mathrm{alt}} < T^{\mathrm{trad}}$. Their diversified portfolios also provide a lower cost of risk-bearing.

3.4.2. Demand for MBTs

Alternative investor *i* maximises expected returns:

$$\max_{T_{i,t}} \mathbb{E}_t \sum_{s=0}^{\infty} \beta_i^s \left[\frac{\lambda^{\mathrm{alt}} P_{t+s}^H}{(1+r_{t+s})^{T^{\mathrm{alt}}}} T_{i,t} - P_t^{\mathrm{MBT}} T_{i,t} \right]. \tag{14}$$

Demand is given by:

$$T_{i,t} = \begin{cases} \infty & \text{if } P_t^{\mathrm{MBT}} < \dfrac{\lambda^{\mathrm{alt}} \mathbb{E}_t P_{t+T^{\mathrm{alt}}}^H}{(1+r)^{T^{\mathrm{alt}}}} \\ 0 & \text{otherwise.} \end{cases} \tag{15}$$

In equilibrium, the MBT price is pinned by alternative investors' recovery expectations:

$$P_t^{\mathrm{MBT}} = \frac{\lambda^{\mathrm{alt}} \mathbb{E}_t P_{t+T^{\mathrm{alt}}}^H}{(1+r)^{T^{\mathrm{alt}}}}. \tag{16}$$

The key insight is that the equilibrium MBT price reflects alternative investors' superior recovery capacity rather than banks' lower recovery rate, generating welfare- improving gains from trade between the two sectors.

3.5. Blockchain Technology

3.5.1. Smart-Contract Benefits

Blockchain provides four distinct efficiency gains.

- Transparency. All market participants observe mortgage characteristics and payment history, eliminating the adverse-selection discount present in traditional bilateral sales. Traditional NPL sale price: $P^{\mathrm{trad}} = (1-\omega)\lambda^{\mathrm{trad}} P_t^H$ where $\omega \in [0.15, 0.30]$. Blockchain price: $P^{\mathrm{BC}} = \lambda^{\mathrm{alt}} P_t^H$ (no asymmetric-information discount).
- **Automation.** Smart contracts reduce operational costs: φtoken = 0.03 versus φtrad = 0.15 for conventional securitisation.
- **Fractional Ownership.** A lower minimum investment ($1,000 versus $10,000,000) broadens the investor base, making alternative-investor supply more elastic and dampening price volatility.
- **Speed.** Instant blockchain settlement reduces resolution time: $T^{\mathrm{BC}} = 1$ period versus $T^{\mathrm{trad}} = 8$ periods.

3.5.2. Technology Adoption

Blockchain infrastructure is available at a fixed cost ΦBC covering platform development and regulatory compliance. Adoption is socially optimal when:

$$\mathrm{NPV}(\mathrm{Blockchain}) > \Phi^{\mathrm{BC}}. \tag{17}$$

In the calibrated model, adoption is optimal for NPL stocks exceeding $50 billion — a threshold readily met during systemic banking crises.

3.6. Production Sector

The production sector follows the standard New Keynesian specification. Output is:

$$Y_t = A_t N_t, \tag{18}$$

and price setting follows a Calvo mechanism giving rise to the New Keynesian Phillips Curve (NKPC):

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa(y_t - y_t^n), \tag{19}$$

where π_t is inflation, κ is the slope of the Phillips Curve, and y_t^n is potential output.

3.7. Monetary Policy

The central bank follows a Taylor rule:

$$R_t = \bar{R} + \varphi_\pi \pi_t + \varphi_y (y_t - y^*) + \varepsilon_t^R, \tag{20}$$

with transmission to mortgage rates mediated by the credit spread:

$$r_t^M = R_t + \text{spread}_t, \tag{21}$$

where the spread is determined by the bank's capital position as given by the first-order condition (13).

3.8. Equilibrium

Definition 3.1 (Competitive Equilibrium). *Given policies* $\{R_t, G_t, T_t\}$ *and blockchain technology* $\{\varphi^{token}, T^{BC}\}$*, a competitive equilibrium consists of allocations, prices, and tokenisation decisions such that*:

(i) households optimise housing consumption, goods consumption, and labour supply;
(ii) banks optimise lending and tokenisation;
(iii) alternative investors optimise MBT purchases;
(iv) firms optimise production and price setting; and
(v) all markets clear: housing, mortgages, MBTs, goods, and labour.

4. Calibration

We calibrate the model to the US economy with particular attention to the 2008 financial-crisis episode.

4.1. Parameters

Table 2 reports all parameter values along with their targets and sources.

4.2. Crisis Scenario

To evaluate blockchain effectiveness, we simulate a 2008-style crisis. The shock sequence is as follows. At $t = 0$, a house-price shock sets $P_0^H = 0.85\bar{P}^H$ (a 15% decline). During $t = 0$ through $t = 4$, the default rate jumps to $\delta_t = 0.12$ (six times the normal rate). A contemporaneous mortgage-demand shock forces household deleveraging. From $t = 5$ onwards, the economy recovers gradually. We compare two economies: the *baseline* economy with traditional resolution only, and the *blockchain* economy in which the MBT market is fully operational.

Parameter	**Symbol**	**Value**	**Target / Source**
Preferences			
Discount factor	β	0.99	4% annual rate
Risk aversion	σ	2.0	Standard
Housing share	$1 - \gamma$	0.15	Housing expenditure share
Housing & Mortgages			
Maximum LTV	θ	0.80	Pre-crisis US average
Default rate (normal)	δ	0.02	2% annual
Default rate (crisis)	δ^{crisis}	0.12	2009–2010 peak
Fire-sale discount	$1 - \lambda^{\text{trad}}$	0.35	35% haircut
Banks			
Mortgage risk weight	κ^M	0.04	Basel III
NPL risk weight	κ^N	0.20	5× higher
Equity issuance cost	Ψ	0.15	Myers–Majluf (1984)
Traditional Resolution			
Foreclosure time	T^{trad}	8 qtrs	24-month US average
Recovery rate	λ^{trad}	0.55	55% of collateral value
Adverse selection	ω	0.25	Opaque bilateral markets
Transaction cost	φ^{trad}	0.15	Legal and servicing costs
Blockchain Resolution			
Tokenisation time	T^{BC}	2 qtrs	6-month pilot evidence
Alt. investor recovery	λ^{alt}	0.75	Expertise premium
Tokenisation cost	φ^{token}	0.03	Smart-contract estimate
Platform fixed cost	Φ^{BC}	\$2bn	Development cost

Monetary Policy			
Taylor: inflation	φ_π	1.5	Standard
Taylor: output gap	φ_y	0.25	Standard

Table 2: Calibration Parameters

5. Quantitative Results

5.1. Crisis Dynamics: Baseline versus Blockchain

5.1.1. Bank NPL Holdings

Table 3 tracks the evolution of NPL stocks as a percentage of bank assets under both resolution regimes.

	Baseline (No Blockchain)			**With Blockchain**		
Quarter	**NPL Stock**	**Resolution**	**Net**	**NPL Stock**	**Tokenised**	**Net**
0 (Crisis start)	2.1	0.3	1.8	2.1	0.0	2.1
1	4.8	0.4	4.4	4.8	2.5	2.3
2	6.9	0.5	6.4	6.9	3.8	3.1
4	8.2	0.6	7.6	8.2	4.2	4.0
8	7.1	0.8	6.3	7.1	3.5	3.6
12	5.4	0.9	4.5	5.4	2.8	2.6
16	3.8	0.7	3.1	3.8	1.9	1.9
20	2.6	0.5	2.1	2.6	1.2	1.4
Note: Figures are percentages of total bank assets. Resolution denotes quarterly disposal via the relevant channel (foreclosure or tokenisation). Net is the residual NPL stock on bank balance sheets. The peak NPL ratio on bank balance sheets falls from 7.6% to 4.0% with blockchain resolution — a reduction of 47%. Faster tokenisation prevents NPL accumulation during the critical early quarters of the crisis.						

Table 3: Non-Performing Loan Evolution (as % of Bank Assets)

5.1.2. Credit Supply

Table 4 reports the evolution of mortgage credit outstanding, indexed to its pre-crisis level.

The credit crunch is 24% shallower under the blockchain regime: the trough is 85.2 rather than 76.8. Cleaner bank balance sheets enable continued lending to productive borrowers throughout the crisis.

5.1.3. House Prices

Table 5 documents the house-price dynamics and the fire-sale mitigation attributable to blockchain resolution.

Quarter	**Baseline**	**Blockchain**	**Difference**
0	100.0	100.0	0.0
2	82.4	88.6	+6.2
4	76.8	85.2	+8.4
8	78.2	87.8	+9.6
12	82.5	92.4	+9.9
16	88.2	96.5	+8.3
20	93.6	98.8	+5.2

Table 4: Mortgage Credit Outstanding (Index, pre-crisis = 100)

Quarter	**Baseline**	**Blockchain**	**Fire-Sale Effect**
0	85.0	85.0	0.0
2	78.2	81.5	+3.3
4	72.8	78.6	+5.8
8	71.4	79.2	+7.8

12	74.2	82.4	+8.2
16	79.5	86.8	+7.3
20	85.2	91.2	+6.0

Table 5: House Price Index (pre-crisis = 100)

The house-price trough is 8.2 percentage points higher under blockchain resolution.

The mechanism is straightforward: in the baseline, banks dump foreclosed properties, depressing prices and triggering further defaults in a destructive feedback loop. Under blockchain resolution, alternative investors acquire tokens and manage properties strategically — as rentals or through phased sales — eliminating the fire-sale externality.

5.2. Transmission Mechanism Analysis

5.2.1. Interest Rate Pass-Through

We estimate the monetary-policy pass-through equation:

$$\Delta r_t^M = \alpha + \beta \Delta R_t + \varepsilon_t. \tag{22}$$

Table 6 summarises the estimated pass-through coefficients across regimes.

Regime	Pass-Through (β^)	Std. Error
Normal times (baseline)	0.82	(0.04)
Crisis — no blockchain	0.42	(0.08)
Crisis — with blockchain	0.68	(0.06)

Table 6: Monetary Policy Transmission to Mortgage Rates

Blockchain resolution restores approximately 62% of the transmission capacity lost during a financial crisis: (0.68 − 0.42)/(0.82 − 0.42) = 0.65. The mechanism is that cleaner bank balance sheets reduce the shadow value of the capital constraint (μt), compressing credit spreads and allowing central-bank rate changes to propagate more fully to mortgage borrowers.

5.2.2. Variance Decomposition

Table 7 presents the structural variance decomposition of output. In the crisis without blockchain, financial shocks (house price and default rate combined) account for 63% of output variance. With blockchain, this share falls to 40%, demonstrating a material dampening of the financial accelerator. Monetary policy shocks, conversely, regain importance because transmission is restored.

Shock	Baseline		Blockchain	
	Normal	Crisis	Normal	Crisis
TFP	58	32	58	42
House price	12	45	12	28
Default rate	8	18	8	12
Monetary	18	4	18	15
Other	4	1	4	3

Table 7: Output Variance Decomposition (%)

5.3. Welfare Analysis

5.3.1. Crisis-Episode Welfare

We compute consumption-equivalent welfare gains using:

V BC !

$$\lambda = \left(\frac{V^{\mathrm{BC}}}{V^{\mathrm{baseline}}} \right)^{\frac{1}{1-\sigma}} - 1. \tag{23}$$

Table 8 summarises the welfare comparison during a crisis episode.

Measure	Baseline	Blockchain
Output loss (peak)	−4.8%	−2.9%
Consumption loss (peak)	−6.2%	−3.7%

Duration (quarters below trend)	24	14
NPV output loss (% of GDP)	−12.4%	−6.8%
Welfare (cons. equivalent)	−8.5%	−5.3%
Welfare gain		+3.2%

Table 8: Welfare Gains from Blockchain Resolution (Crisis Period)

Blockchain infrastructure is worth a 3.2% permanent consumption increase during crisis periods, relative to the traditional-resolution economy.

5.3.2. Decomposition of Welfare Gains

The aggregate welfare gain decomposes across four channels.

- **Faster deleveraging (40%).** NPLs clear 18 months sooner, enabling banks to resume lending more rapidly and improving consumption smoothing.
- **Higher recovery rates (30%).** The alternative-investor recovery rate of $\lambda\mathrm{alt} = 0.75$ exceeds the traditional rate of $\lambda\mathrm{trad} = 0.55$, preserving an additional \$200 billion in bank capital that is then directed to productive investment.
- **Reduced fire sales (20%).** House prices decline 8 percentage points less, preserving homeowner wealth and supporting consumption through the wealth effect.
- **Better monetary transmission (10%).** Restored pass-through increases the effectiveness of central-bank stabilisation policy.

5.4. Counterfactual: 2008 Financial Crisis

We apply our calibrated model to actual 2008 crisis data. The key assumptions are: US banks held \$1.4 trillion in NPLs at peak (Q1 2010); blockchain technology would have facilitated tokenisation of 75% of those NPLs (\$1.05 trillion); the average recovery under blockchain resolution would be 75 cents versus 55 cents on the dollar, preserving \$210 billion in bank capital.

Table 9 reports the comparison between actual outcomes and the blockchain counterfactual.

Outcome	**Actual (2008–2010)**	**Counterfactual (w/ Blockchain)**
GDP decline (trough)	−4.3%	−2.4%
Unemployment (peak)	10.0%	7.8%
House-price decline	−33%	−25%
Bank failures	489	280
Credit contraction	−18%	−9%
Recovery time (years)	6.5	3.8
Output saved		\$1.2 trillion (8.5% of GDP)
Jobs saved		3.2 million

Table 9: 2008 Financial Crisis Counterfactual Analysis

The counterfactual results are striking: blockchain infrastructure could have prevented \$1.2 trillion in output losses, halved the credit contraction, averted over 200 bank failures, and reduced peak unemployment by 2.2 percentage points.

5.5. Sensitivity Analysis

5.5.1. Alternative Investor Recovery Rate

Table 10 shows that welfare gains are monotonically increasing in the alternative investor's recovery expertise. Even a modest 10% recovery premium over the traditional rate generates economically meaningful benefits.

$\lambda\mathrm{alt}$	**Recovery Premium**	**MBT Price**	**Welfare Gain**
0.60	9% (marginal)	0.58	+1.2%
0.65	18%	0.62	+1.8%
0.70	27%	0.67	+2.5%
0.75	36% (baseline)	0.72	+3.2%
0.80	45%	0.77	+3.8%
0.85	55%	0.82	+4.3%

Table 10: Welfare Gains versus Alternative Investor Recovery Rate

5.5.2. Tokenisation Cost

Table 11 demonstrates that blockchain remains welfare-improving across a wide range of tokenisation costs. Even if costs reach the level of traditional securitisation (15%), the mechanism still delivers positive net welfare gains.

φtoken	Net Recovery	Welfare Gain
0.01 (optimistic)	74%	+3.6%
0.03 (baseline)	72%	+3.2%
0.05	70%	+2.8%
0.10	65%	+2.1%
0.15 (parity with traditional)	60%	+1.2%

Table 11: Welfare Gains versus Tokenisation Transaction Cost

6. Optimal Regulatory Design

6.1. Permissioned versus Permissionless Blockchain

A permissionless blockchain (e.g., public Ethereum) maximises decentralisation and eliminates gatekeepers, but exposes markets to regulatory uncertainty, AML/KYC challenges, and cyber risk. A permissioned consortium blockchain (e.g., JPMorgan Onyx) embeds regulatory compliance and restricts participation to known counterparties, but introduces centralisation risk and potential rent-seeking.

Formally, social welfare under the two architectures satisfies:

$$W^{\text{permissionless}} = W^{\text{baseline}} + \Delta W_{\text{eff}} - \Delta W_{\text{risk}}, \quad (24)$$

$$W^{\text{permissioned}} = W^{\text{baseline}} + 0.8 \cdot \Delta W_{\text{eff}} - 0.2 \cdot \Delta W_{\text{risk}}, \quad (25)$$

where efficiency gains are 20% lower under the permissioned architecture (reflecting slower innovation and potential rent extraction) but risks are 80% lower.

For systemic mortgage markets with material retail exposure, the permissioned architecture dominates whenever:

$$\frac{\Delta W_{\text{risk}}}{\Delta W_{\text{eff}}} > 0.22. \quad (26)$$

Calibration yields $\Delta W_{\text{risk}}/\Delta W_{\text{eff}} \approx 0.35$, so the permissioned architecture is unambiguously optimal for mortgage-market applications.

6.2. Investor Qualification Requirements

A central regulatory question is whether MBT trading should be restricted to accredited or qualified institutional investors. Open access maximises liquidity and price discovery but exposes unsophisticated retail investors to complex distressed-asset risks. Restricted access protects retail participants but thins the market.

The social welfare comparison under open access (investor base $I^{\text{open}} = I^{\text{acc}} + I^{\text{retail}}$) is:

W^{open} = E[Gains from liquidity] − Pr(retail losses) × Loss magnitude. (27)

Calibration reveals that retail investors add 30% to the investor base and raise MBT prices by 8%, but suffer average losses of 15% on direct MBT purchases due to limited expertise in distressed-asset workouts. The social cost of retail losses is approximately twice the private loss owing to behavioural biases and limited-liability puts.

Optimal policy: Allow retail investors to access MBTs indirectly through funds or ETFs managed by qualified professionals, while restricting direct MBT purchases to accredited investors. This design achieves 85% of the liquidity benefit of full open access while eliminating 90% of the retail-loss risk.

6.3. Central Bank Collateral Framework

Should central banks accept MBTs as collateral for discount-window lending? The argument in favour is that acceptance would enhance MBT market liquidity (raising equilibrium prices and improving NPL resolution), provide emergency liquidity to banks holding MBTs in a crisis, and bolster monetary-policy transmission. The argument against is that it exposes the central bank's balance sheet to credit risk, creates moral hazard by subsidising risk-taking, and blurs the boundary between monetary and fiscal policy.

The central bank accepts MBTs at haircut h, so the collateral value is:

$$\text{Collateral value} = (1 - h) \times P_t^{\text{MBT}} \times \text{MBT quantity}. \quad (28)$$

The optimal haircut solves:

$$h^* = \arg\max_h \left[W(\text{liquidity} \mid h) - \mathbb{E}[\text{Central Bank losses} \mid h]\right]. \quad (29)$$

- **Proposition 6.1.** *The optimal central-bank haircut is h□ = 0.40 (60% loan-to-value).*
  Rationale. At equilibrium, MBT prices are approximately 0.72 of par, with an expected recovery of 75% and a 20% volatility. A 40% haircut ensures that the central bank is fully repaid with 99% probability. The marginal welfare gain from accepting MBTs as collateral is +0.5%.

6.4. Automatic Stay Provisions

Regulators may impose temporary circuit breakers on MBT trading during financial crises to prevent panic-driven price spirals. If the MBT price falls more than 30% in a single trading session, trading is halted for 24 hours to allow information aggregation.

The trade-off is that circuit breakers reduce panic selling and stabilise prices, but may signal fragility and exacerbate selling when trading resumes. Simulations show that circuit breakers reduce price volatility by 15–20% with no evidence of a delayed crash, generating a welfare gain of +0.2%.

Recommendation: Implement circuit breakers at a 30% daily decline threshold.

6.5. Comprehensive Optimal Regulatory Package

Table 12 summarises the optimal regulatory framework derived from the preceding analysis.

Dimension	Optimal Policy	Rationale
Platform type	Permissioned consortium	Balance efficiency and safety
Governance	Banks plus regulatory oversight	Systemic risk mitigation
Investor access	Accredited direct; retail via funds	Protect unsophisticated investors
Minimum investment	$5,000	Meaningful diversification
Smart-contract auditing	Mandatory third-party audit	Code security
Data transparency	Full on-chain; KYC offchain	Privacy–transparency balance
CB collateral	Accepted at 40% haircut	Liquidity support, risk management
Circuit breakers	30% daily decline trigger	Panic prevention
Capital treatment	50% risk weight for bankheld MBTs	Encourage NPL distribution
Deposit insurance	No coverage for MBT losses	Maintain market discipline

Table 12: Optimal Regulatory Framework for Blockchain Mortgage Markets

7. Policy Implications and Implementation

7.1. For Central Banks

- **Embrace Blockchain Infrastructure.** Central banks should develop CBDC infrastructure compatible with MBT platforms, sponsor industry consortia for permissioned blockchain development, accept MBTs as discount-window collateral with appropriate haircuts, and monitor MBT markets as leading indicators of financial stress.
- **Adjust the Monetary Policy Framework.** Recognition that blockchain improves transmission in normal times and is especially valuable in crises — when it prevents complete transmission breakdown — may require recalibration of Taylor-rule coefficients to account for faster credit-market responses.
- **Financial Stability Mandate.** MBT markets enhance stability through faster NPL resolution, broader risk distribution, and real-time price signals that enable earlier crisis detection. However, they introduce new vulnerabilities: cyber attacks on blockchain infrastructure, smart-contract bugs, and market fragmentation across incompatible platforms. Central banks should establish dedicated blockchain-stability oversight units, subject MBT markets to stress testing, and develop contingency plans for platform failures.

7.2. For Banking Regulators

- **Capital Requirements.** Current Basel III treatment applies uniform risk weights across mortgage categories. We propose a differentiated framework: NPLs on bank balance sheets retain a 100% risk weight; NPLs tokenised but not yet sold attract a 75% risk weight; MBTs acquired as investments carry a 50% risk weight, reflecting their superior liquidity and transparency. This graduated structure creates a regulatory incentive for banks to tokenise and distribute NPLs promptly.
- **Liquidity Requirements.** MBTs should qualify as High-Quality Liquid Assets Level 2B (with a 50% haircut) subject to three conditions: listing on a regulated exchange; minimum outstanding issuance of $100 million; and annual price volatility below 25%. This recognition acknowledges that MBTs are materially more liquid than traditional NPLs.
- **Disclosure Requirements.** Banks holding or issuing MBTs must disclose: portfolio composition by geography, vintage, and LTV distribution; real-time default rates updated monthly; recovery progress by foreclosure stage; and open-source smart-contract code available for independent verification.

7.3. For Securities Regulators

- **MBT Classification.** Regulators should confirm that MBTs constitute securities satisfying the Howey test, requiring issuers to register or qualify for an exemption (e.g., Regulation D for accredited investors) and exchanges to register as Alternative Trading Systems. Market manipulation rules apply in full.
- **Investor Protection.** Mandatory risk disclosures should clearly state that MBTs are high-risk investments backed by distressed mortgages. Expected recovery ranges should be presented with supporting historical data. Smart-contract risks, liquidity risks, and cyber-security risks should all be highlighted. A 48-hour cooling-off period between account opening and the first MBT purchase provides additional protection.
- **Market Surveillance.** Real-time monitoring should target

wash trading (artificial liquidity creation), pump-and-dump schemes, and insider trading by banks with information advantages. Blockchain transparency materially facilitates such surveillance because all transactions are permanently visible on-chain.

7.4. For Fiscal Authorities

- **Tax Treatment.** MBT trading gains and losses should be treated as capital gains for tax purposes, consistent with stocks and bonds. Alternative investors should be permitted to deduct restructuring costs. Banks should be allowed to recognise losses immediately upon tokenisation rather than waiting for the completion of foreclosure proceedings.
- **Government-Sponsored Entities.** Fannie Mae and Freddie Mac collectively hold over $50 billion in NPLs. Tokenisation could yield $10–15 billion in additional recovery, directly benefiting taxpayers. We recommend a pilot programme involving a $5 billion NPL tranche to evaluate feasibility before scaling to the full GSE portfolio.

7.5. Implementation Roadmap

- **Phase 1 — Foundation (Years 1–2).** Establish an industry consortium of banks, technology firms, and regulators. Launch a regulatory sandbox for pilot tokenisation programmes. Develop smart-contract standards and interoperability protocols. Conduct investor education campaigns to build awareness and trust.
- **Phase 2 — Scaling (Years 3–4).** Complete the first $10 billion in NPL tokenisations. Launch two to three competing exchanges. Implement the central-bank collateral framework. Seek Basel Committee guidance to establish international coordination.
- **Phase 3 — Maturity (Year 5 onwards).** Establish routine NPL tokenisation covering 50% or more of newly distressed assets. Develop MBT market liquidity comparable to the investment-grade corporate-bond market. Integrate the MBT infrastructure with CBDC platforms. Extend the tokenisation framework to other asset classes including commercial real estate, automobile loans, and credit cards.

8. Conclusion

This paper develops the first macroeconomic framework for blockchain-enabled mortgage markets as a financial-stability instrument.

8.1. Main Findings

The analysis yields five principal findings.

- **Theoretical.** Blockchain tokenisation creates a liquid secondary market for distressed assets, reducing bank balance-sheet impairment and accelerating the deleveraging necessary for economic recovery.
- **Quantitative.** NPL resolution time falls by 75% (from 28 months to 7 months); crisis output losses decline by 45%; and the welfare gain is equivalent to a 3.2% permanent increase in consumption.
- **Transmission.** Monetary-policy pass-through to mortgage rates rises from 0.42 to 0.68 in crisis periods, because blockchain resolution prevents the complete breakdown of the credit channel.
- **Counterfactual.** Applied to the 2008 crisis, blockchain infrastructure could have saved $1.2 trillion in output (8.5% of GDP) and 3.2 million jobs.
- **Regulatory.** Optimal design combines a permissioned consortium blockchain, accredited investor requirements for direct participation, central-bank collateral acceptance at a 40% haircut, and 30% circuit breakers.

8.2. Contributions

- **Theoretical Contributions.** This paper presents the first DSGE model that integrates blockchain technology with the banking sector and distressed-asset markets. We introduce an endogenous resolution technology choice between traditional foreclosure and tokenisation, and derive optimal regulation of decentralised financial infrastructure in a general-equilibrium setting.
- **Policy Contributions.** We provide a concrete analytical framework for central banks and regulators considering blockchain adoption, quantify the welfare gains sufficient to justify infrastructure investment, and identify the key risks together with targeted mitigation strategies.

8.3. Limitations and Future Research

Several limitations of the present analysis merit acknowledgement. The model abstracts from heterogeneity in mortgage characteristics (prime versus subprime). The alternative investor sector is simplified, abstracting from strategic interactions and market power. There is no international dimension to the model, so cross-border MBT contagion is not addressed. Cyber-security risks are treated as exogenous shocks rather than being modelled endogenously.

These limitations open productive avenues for future research. As MBT markets develop, empirical validation of the model's predictions will become possible. Fully optimal monetary policy rules for a blockchain economy remain to be derived. International spillovers through global MBT markets deserve careful analysis. Extensions to commercial real estate, automobile loans, and credit cards would test the generality of our framework. Distributional analysis — identifying who gains and who loses from blockchain adoption among banks, borrowers, investors, and taxpayers — is both practically important and under-studied. Finally, the political economy of adoption — why blockchain has not yet been more widely embraced, given the welfare gains identified here — is an important question, with regulatory capture and incumbent resistance as plausible explanations.

8.4. Final Remarks

Financial crises impose enormous economic and social costs. The 2008 crisis caused over $10 trillion in output losses globally, 20 million job losses, and contributed to lasting political disruption. Traditional policy responses — monetary easing, fiscal stimulus, and bank bailouts — are necessary but insufficient: they address symptoms such as liquidity deficiency and demand weakness rather than the root cause of impaired bank balance sheets.

Blockchain technology offers a structural solution: transforming illiquid, opaque distressed assets into tradable, transparent securities accessible to specialised investors with genuine expertise in recovery management. This approach accelerates the deleveraging process essential for crisis resolution, which in its absence typically requires years of economic stagnation to work through.

Our analysis shows the potential is substantial: $1.2 trillion saved in a 2008-scale crisis and a 3.2% permanent welfare gain. But realising this potential requires careful institutional design. Policymakers must balance innovation benefits against risks, protect unsophisticated investors while maintaining market liquidity, and coordinate internationally to prevent regulatory arbitrage.

The technology exists. The economic case is clear. The remaining challenge is implementation — building the regulatory, legal, and market infrastructure needed to harness distributed-ledger technology for financial stability. This paper provides a framework and a roadmap; the next step is action.

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A. Mathematical Appendix

A.1. Derivation of Bank Lending First-Order Condition

The bank's optimisation problem is:

$$\max_{M_{j,t+1}} \mathbb{E}_t \Lambda_{t,t+1} \left[r_t^M M_{j,t+1} - r_t^D D_{j,t+1} + \cdots \right] \qquad (30)$$

subject to the capital constraint:

$$E_{j,t} \geq \kappa^M M_{j,t+1} + \kappa^N N_{j,t+1}. \qquad (31)$$

Forming the Lagrangian:

$$\mathcal{L} = \mathbb{E}_t \Lambda_{t,t+1} \Pi_{j,t+1} + \mu_t \left[E_{j,t} - \kappa^M M_{j,t+1} - \kappa^N N_{j,t+1} \right], \quad (32)$$

and differentiating with respect to Mj,t+1:

$$r_t^M - r_t^D - \mu_t \kappa^M - \beta\, \mathbb{E}_t \Lambda_{t,t+1} \delta_{t+1} \left[\kappa^N - P_{t+1}^{\text{MBT}} (1 - \varphi^{\text{token}}) \right] (33)$$

Rearranging yields equation (13) in the main text.

A.2. MBT Equilibrium Price

Alternative investors demand MBTs if and only if:

$$P_t^{\text{MBT}} \leq \frac{\lambda^{\text{alt}} \mathbb{E}_t P_{t+T^{\text{alt}}}^H}{(1+r)^{T^{\text{alt}}}}. \qquad (34)$$

Banks supply MBTs if and only if:

$$P_t^{\text{MBT}} (1 - \varphi^{\text{token}}) \geq \frac{\lambda^{\text{trad}} P_t^H}{(1+r)^{T^{\text{trad}}}}. \qquad (35)$$

Market clearing requires:

$$\text{Supply}(\tau^* N_t) = \text{Demand}(P_t^{\text{MBT}}). \qquad (36)$$

In equilibrium, the MBT price is:

$$P_t^{\text{MBT}} = \min \left\{ \frac{\lambda^{\text{alt}} \mathbb{E}_t P_{t+T^{\text{alt}}}^H}{(1+r)^{T^{\text{alt}}}}, \; \frac{1}{1 - \varphi^{\text{token}}} \cdot \frac{\lambda^{\text{trad}} P_t^H}{(1+r)^{T^{\text{trad}}}} \right\}. \quad (37)$$

When λalt > λtrad and Talt < Ttrad — the empirically relevant case — the alternativeinvestor demand constraint binds and the equilibrium price is determined by equation (16) in the main text.

B. Computational Algorithm

The model is solved in Dynare (version 5.5) using the following numerical strategy.

- **Second-order perturbation.** The model is approximated to second order around its non-stochastic steady state to capture precautionary savings and risk-premium effects relevant to crisis dynamics.
- **Particle filter for regime switching.** A bootstrap particle filter with N = 10,000 particles accommodates the crisis-regime switching in the default-rate process δt.
- **Simulated method of moments (SMM).** Calibration targets are matched via SMM, minimising the weighted distance between model-simulated moments and empirical counterparts. The weighting matrix is the inverse of the empirical variance–covariance matrix of the target moments.
- **Counterfactual analysis.** Counterfactual scenarios are simulated by replacing historical shock realisations with model-implied paths, holding the equilibrium conditions and parameter values constant. Replication code is available upon request from Dr Gazi Arif.