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Digital Rupee: An Assessment of Central Bank Digital Currency Design and Implications

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ABSTRACT

Retail Central Bank Digital Currency brings a direct liability of the central bank into the household portfolio and questions the stability of the bank deposit. This research paper assesses the issue of whether scaling the Digital Rupee creates disintermediation risk in India. Based on March 2025 banking aggregates, with the deposits being ₹225.21 trillion and the Digital Rupee balances being negligible, a calculated balance sheet framework is built. The model differentiates between steady state substitution and amplification of stress and includes holding limits, inclusion offsets, and funding replacement capacity. Findings show that substitution at a cost from 0 up to 1 percent is economically insignificant, however beyond 1 percent, substitution is nonlinear and rises with adoption of 3-5 percent under pressure. Holding limits contain extreme results, while inclusion contains relative widespread influences but decays with scale. Disintermediation risk is a conditional and interaction-based risk that only arises when scale and stress are in line.

Keywords: Central Bank Digital Currency, Digital Rupee, Bank Disintermediation, Financial Stability, Stress Amplification, Nonlinear Risk.

1. INTRODUCTION

Central Bank Digital Currency presents a risk-free electronic substitute to bank deposits. In deposit-driven systems like India, it brings about an issue of stability in funding. By March 2025, deposits will be ₹225.21 trillion and balances of Digital Rupee are insignificant. A one percent migration means over ₹2 trillion in funding realignment, whereas five percent is close to ₹11 trillion. Even small proportional changes therefore carry material implications. The available literature is concentrated on the steady state substitution and has little effect. However, this perspective underestimates stress conditions, where depositor behavior becomes more sensitive and switching frictions decline. The interaction between adoption scale and stress intensity becomes central to systemic risk.

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This paper constructs a sensitive scale framework that interconnects the adoption of CBDC to deposit stability by interacting with behavioural reaction and institutional constraints within a big emerging banking system.

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2. REVIEW OF LITERATURE

Literature on CBDC disintermediation can be grouped into four strands.

A. Steady State Substitution

Studies indicate that under normal circumstances, substitution is low because of the returns of bank deposits. Large scale migration is discouraged by non-interest bearing CBDC.

B. Stress Amplification

Online connectivity minimizes switching costs. When stressed, withdrawal behavior is no longer linear and is large in an exaggerated proportion to perceived risk changes.

C. Design Safeguards

Stabilizing mechanisms are suggested to be holding limits and non-remuneration. Their usefulness is determined by their binding at system scale.

D. Dynamics of the Emerging Market

The net effect of inclusion during early adoption is less net substitution. Substitution by old depositors however predominates as the adoption grows.

Research Gap

Many studies have not been pegged to large deposits systems and they do not collectively model scale, stress and institutional constraints. This limits practical applicability.

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3. METHODOLOGY

The analysis is done with a calibrated balance sheet framework that is anchored on the banking aggregates of March 2025. The adoption of CBDC is presented in a form of a ratio of total deposits.

$$\text{Gross Shift} = \alpha \times \text{Deposits}$$

$$\text{Stress Shift} = \alpha \times \beta \times \text{Deposits}$$

$$\text{Net Shift} = \text{Stress Shift} \times (1 - \theta)$$

$$\text{Credit Impact} = (1 - \gamma)(1 - \rho) \times \text{Net Shift}$$

Where alpha represents the adoption, beta represents stress amplification, theta represents offsetting inclusion, gamma represents funding replacement capacity, and rho represents insured deposit share. The framework combines deterministic threshold analysis with bounded Monte Carlo simulation. Threshold analysis identifies structural breakpoints while simulation evaluates sensitivity across parameter combinations.

Table 1: Variable Definition

Variable	Definition	Value
Total Deposits	Banking system base	₹225.21 trillion
Digital Rupee	Observed balance	₹0.01 trillion
Adoption Share	CBDC as % of deposits	0.00444%

MODELING AND ANALYSIS

The model combines three interconnected processes.

First, the substitution of the baseline is restricted in normal conditions. Digital Rupee functions primarily as a payment instrument rather than a store of value.

Second, substitution intensity is enhanced by stress amplification. Reduced switching frictions enable faster migration into central bank liabilities. Behavior becomes nonlinear and sensitive to perceived risk.

Third, the results are transformed by institutional modifiers. Inclusion offsets lessen initial phase impacts; financing of replacement establishes transmission of credit and extreme migration is restricted by holding limits.

System outcomes are dependent on the interaction of these mechanisms. Exposure is defined by scale, amplification is governed by stress and transmission by the funding capacity.

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4. RESULTS AND DISCUSSION

This part assesses the dynamics of the contraction of deposits with respect to adoption levels and stress conditions with calibrated scenarios.

A. Baseline Dynamics

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At low levels of adoption, deposit substitution is an economically unimportant phenomenon. CBDC balances held below 1 percent of total deposits imply contraction will not exceed about ₹2 trillion as compared to the system size. This implies that early adoption represents substitution of payments and not disruption of structural funds.

B. Stress Amplification

In stress condition, deposit contraction grows nonlinearly. With adoption of between 3-5 percent, behavioral response increases and generates disproportionately higher outflows.

Table 2: Nonlinear Stress amplification Effect

Adoption	Stress Multiplier (β)	Deposit Shift	% of Deposits
1%	2	₹4.5 trillion	2%
1%	4	₹9 trillion	4%
5%	4	₹45 trillion	20%

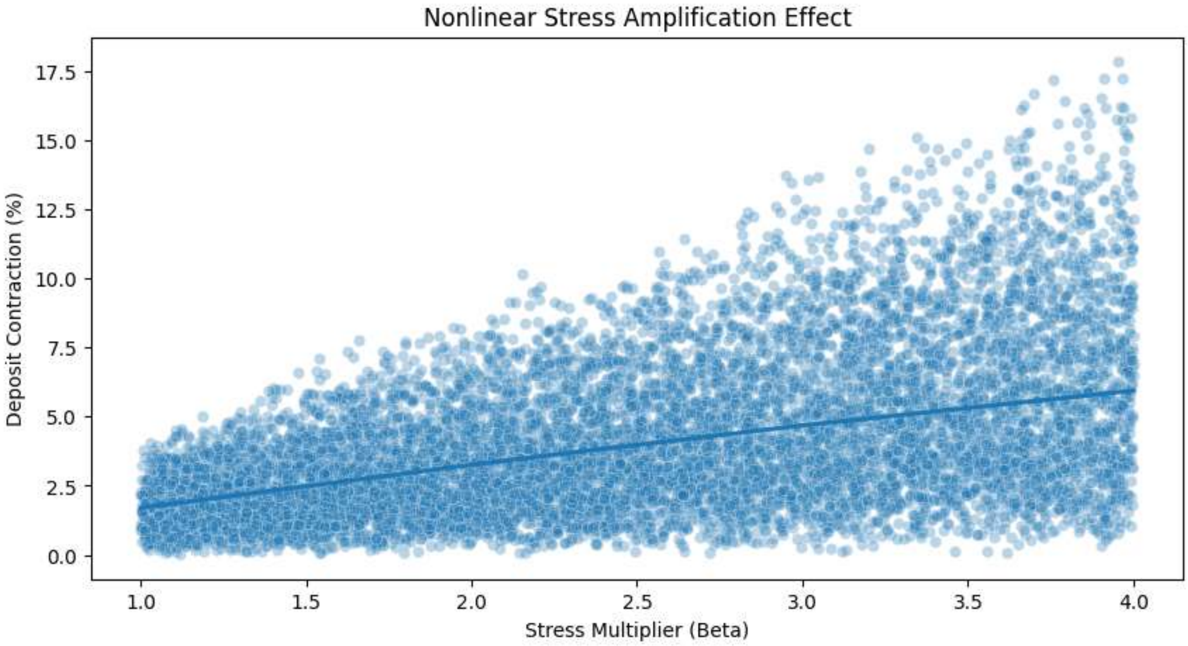

Figure 1: Nonlinear Stress Amplification Effect

Figure 1 illustrates the convex relationship between adoption and deposit contraction under varying stress levels. Scale alone does not generate risk. Risk emerges when adoption interacts with stress intensity.

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C. Credit Transmission

The impact on lending depends on funding replacement capacity rather than deposit loss alone.

Table 3: Lending Impact

Deposit Loss	Estimated Credit Impact
₹4.5 trillion	2.46%
₹9 trillion	4.93%
₹45 trillion	>20%

When funding replacement is strong, lending remains stable. When constrained, credit contraction becomes significant. This establishes that transmission to the real economy depends on institutional flexibility.

Lending is stable when the funding replacement is high. Constrained credit contraction is important when there is constraint. This confirms that the flow to the actual economy relies on institutional malleability.

D. Inclusion Offset

The effects of inclusion decrease net contraction of deposits in the initial phases of adoption. The adoption by previously unbanked customers compensates with replacement of existing deposits. But as the adoption increases, the substitution takes over and the offset becomes weak. The effect of inclusion on risk status in the early-stage levels is moderating but not averting at the higher levels.

E. Holding Limits

Holding limits are binding restraints mainly in high adoption and high stress situations. They squeeze the extreme results but do not have material impact on medium substitution behavior.

F. Distribution and Tail Risk

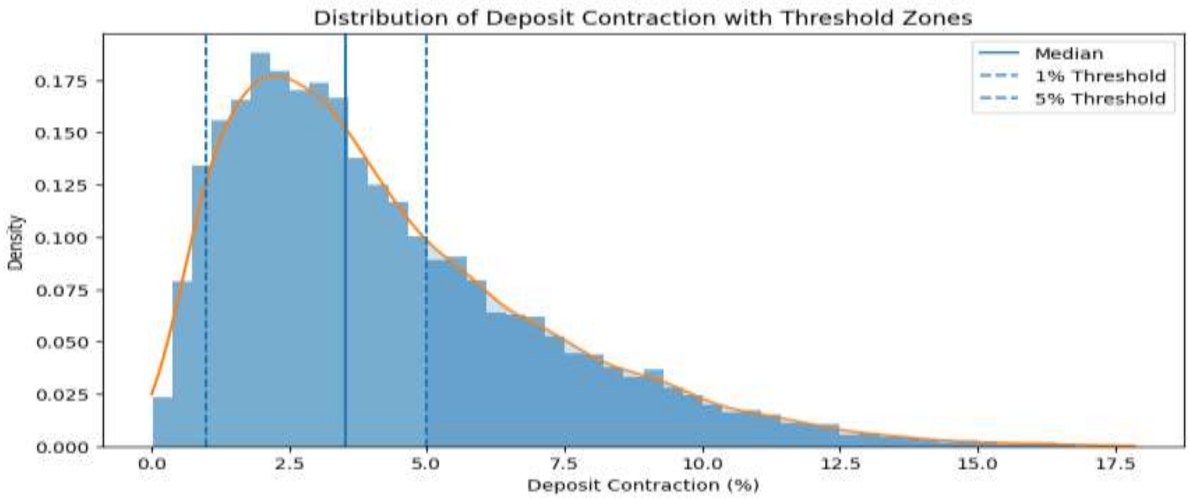

Figure 2: Distribution of Deposit Contraction with treshold zones

Figure 2 shows the contraction of deposits in each of the simulation scenarios. It is a right skewed distribution, which shows the lack of the median impact and large upper tail results.

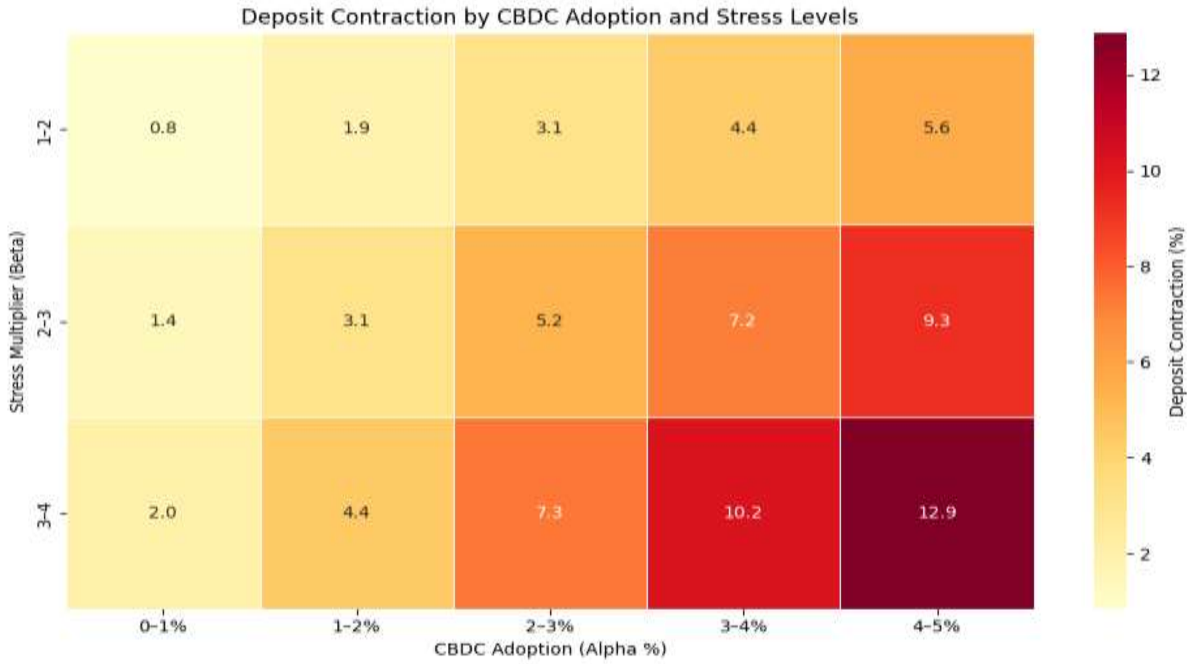

Figure 3: Heatmap of Deposit Contraction

This shows an interaction heatmap according to the parameters of adoption and stress. High impact zones occur when both the variables are high at the same time.

SYNTHESIS

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In all situations, the effects of interactions control the results. Scale defines exposure, stress amplification determines funding capacity and transmission is defined by scale. It is disintermediation risk thus a threshold phenomenon and not a linear process.

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5. CONCLUSION

Digital Rupee is not a threat to the banking stability in India. Substitution at current levels is economically unimportant and does not have a significant impact on deposit funding. The risk only comes out when adoption becomes structural in terms of thresholds and is combined with stress conditions. At a level below 1 percent adoption, the effects are insignificant. Nonlinear amplification is observed between 35 percent. Institutional mechanisms reshape outcomes but do not eliminate risk. Holding limits squeeze extreme situations, inclusion offsets level off early effects and funding replacement identifies the degree of credit transmission.

Disintermediation risk is not driven by adoption alone, but by how scale interacts with stress and institutional capacity. The management of this interaction should be the focus of effective policy instead of limiting the adoption of CBDC.

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6. Limitations of Study

1. Static framework

The model is scenario-driven and lacks in dynamic adjustment with time, such as the way depositor behavior changes with increased adoption or during long-lasting stress.

2. Calibrated parameters

The amplification of stress and inclusion offset are core variables that are assumed instead of estimated empirically, which restricts the ability to be accurate in the real world.

3. Aggregate-level analysis

The framework considers the banking system to be homogeneous and fails to reflect the differences between banks in terms of liquidity, size, and the funding structure.

4. Absence of endogenous feedback

The model fails to model the feedback loops in which initial deposit outflows may lead to increased withdrawals, which may increase systemic stress.

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