

The Impact of Central Bank Digital Currency on the Money Multiplier: A Comparative Analysis of Design Schemes across Countries

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Abstract

The research, development and piloting of central bank digital currency (CBDC) are profoundly affecting the transmission mechanism of monetary policy. Starting from the constituent elements of the money multiplier, this paper constructs an institutional analysis framework covering three dimensions, namely interest-bearing rules, operational architecture and substitution targets, and, based on a comparison among three representative schemes (China's e-CNY, Sweden's e-krona and the Bahamas' Sand Dollar), examines the differentiated mechanisms of money multiplier changes under different institutional arrangements. The study finds that interest-bearing rules determine whether a CBDC possesses saving attributes and the intensity of its substitution for deposits; the operational architecture determines the intermediary position of commercial banks in the credit-creation chain; and the substitution target and holding constraints determine the potential scale of deposit disintermediation. A design that is non-interest-bearing and positioned as a cash substitute can minimize the shock to the money multiplier, whereas an interest-bearing model and a high-limit design will significantly strengthen the deposit-substitution effect and trigger financial disintermediation risk, and the two-tier operational architecture constitutes an important institutional line of defense for mitigating the shock. Accordingly, this paper proposes policy recommendations such as maintaining the non-interest-bearing positioning, preserving two-tier operation, and dynamically adjusting holding caps.

Keywords

central bank digital currency, money multiplier, interest-bearing rules, operational architecture, deposit disintermediation

1. Introduction

Advances in digital technology have driven the spread of private digital currencies and mobile payments. In response, central banks in many countries have successively launched research and pilot programs on central bank digital currencies (CBDCs), aiming to preserve the public-good nature of fiat money and monetary sovereignty in the digital economy. A CBDC is legal tender issued by the central bank in digital form. Its legal attributes and credit rating are equivalent to those of cash, yet its holding and transaction costs are lower. Its introduction alters the internal composition of the monetary base and the liability structure of commercial banks, thereby acting on the money multiplier, the key variable linking the monetary base to the money supply.

When the public converts a portion of bank deposits into CBDC, the loanable funds of commercial banks shrink, and the money-creation process is disrupted.

Therefore, the direction of a CBDC's impact on commercial banks' credit-creation capacity, and its heterogeneity across different institutional designs, constitute an important issue for assessing its macroeconomic effects. Existing studies largely examine the impact of CBDCs on the money multiplier and macro-financial effects through balance-sheet channels or dynamic stochastic general equilibrium frameworks [1-3], while the international literature focuses on issues such as interest-bearing arrangements and design principles [4-6]. Most of these studies, however, take a single country's specific model as the analytical premise and lack a cross-country comparison that accounts for design heterogeneity.

By comparing three representative schemes, namely China's digital renminbi (e-CNY), Sweden's e-krona, and The Bahamas' Sand Dollar, this paper reveals the differentiated mechanisms of money-multiplier change under different institutional arrangements. The marginal contributions of this paper are threefold. First, it introduces the heterogeneity of design schemes into the money-multiplier analytical framework and broadens the cross-country comparative perspective. Second, it clarifies the multiple channels through which a CBDC affects the money multiplier and their institutional dependence. Third, it provides a theoretical basis for the policy regulation and institutional optimization of the digital renminbi.

2. Theoretical Framework for the Impact of CBDC on the Money Multiplier

The traditional money-multiplier model rests on a dual structure in which the central bank issues cash and commercial banks take deposits and hold reserves. The monetary base consists of cash in circulation and reserves, while broad money consists of cash and deposits. The money multiplier m is jointly determined by the required reserve ratio r_d , the excess reserve ratio e , and the cash leakage ratio k :

$$m = \frac{1+k}{r_d+e+k} \quad (1)$$

As shown in Equation (1), the money multiplier moves inversely with all three parameters, which serves as the theoretical starting point for analyzing the impact of a CBDC. The introduction of a CBDC breaks the dual structure and expands the public's asset allocation into a combination of cash, bank deposits, and CBDC. Its impact manifests through changes in the parameters. If it mainly substitutes for cash, the scale of the monetary base need not change significantly because both are central-bank liabilities, and the change in the money multiplier remains relatively limited. If it substitutes for bank deposits, this amounts to converting commercial-bank liabilities into central-bank liabilities, shrinking banks' loanable funds and weakening their money-creation capacity. In addition, the statistical definition of money interacts with institutional design. If a CBDC is classified into M1 or M2, both the numerator and the denominator of the multiplier are disturbed simultaneously.

Furthermore, institutional design shapes the direction and magnitude of money-multiplier changes through three channels. The first channel concerns interest-bearing rules. A non-interest-bearing design makes the CBDC mainly a payment instrument and limits its substitution for savings deposits. When interest is paid and the rate approaches or exceeds the demand-deposit rate, the CBDC becomes a substantial substitute for deposits, triggering deposit disintermediation and credit contraction [4]. The competitive structure of the banking sector affects the net effect of interest-bearing arrangements [5, 7]. The second channel concerns operational architecture. Under a single-tier architecture, the central bank issues CBDC directly to the public, commercial banks are excluded from credit intermediation, and the money-multiplier amplification mechanism is greatly weakened. A two-tier architecture preserves the intermediary role of commercial banks and cushions the liability-side shock [6]. The third channel concerns the substitution target and quota limits. If only cash is substituted, the shock is small. If deposit substitution is permitted without holding limits, the public may convert deposits into CBDC en masse during periods of financial stress, causing a sharp contraction of the money multiplier [8, 9]. Tiered limits are an important institutional tool for curbing deposit disintermediation [10].

3. Institutional Comparison of CBDC Design Schemes across Countries

This paper selects three representative retail CBDC schemes, China's e-CNY, Sweden's e-krona, and the Bahamas' Sand Dollar, for comparison. The three follow different design paths and cover key combinations within the CBDC design space.

3.1 China's e-CNY: Non-Interest-Bearing, Two-Tier Operation, and M0 Substitution

The e-CNY is positioned as M0, pays no interest, and follows a two-tier operational architecture. The People's Bank of China is responsible for issuance and registration, while designated operating institutions handle exchange and circulation services [11]. The non-interest-bearing design prevents direct competition with deposits in terms of returns. Its substitution target is concentrated in retail payment scenarios, so the direct shock to the deposit system is limited. The tiered wallet system sets balance and transaction limits according to the degree of real-name verification and risk level, which restrains the motive for large-scale deposit conversion and mitigates disintermediation risk. These design features keep the potential shock of the e-CNY to the money multiplier within a limited range. In terms of the constituent parameters of the money multiplier, this combination means that the rollout of the e-CNY is mainly reflected in a mild increase in the cash leakage ratio. The public uses the e-CNY to replace circulating cash rather than bank deposits, leaving the reserve ratio and the time deposit ratio essentially unaffected. In addition, the two-tier operation ensures that the exchange process does not directly consume bank reserves. As a result, the change in the money multiplier is small and remains gradual as the pilot expands.

3.2 Sweden's e-krona: Interest-Bearing Scheme and Deposit Substitution

Sweden is among the economies where cash use has declined most markedly, and public reliance on cash has kept falling. This trend is a direct motivation for its work on the e-krona. The e-krona's design discussions explicitly consider an interest-bearing option [12]. If no interest is paid, its function resembles cash and its impact on deposits is limited, but it sets a de facto zero lower bound on the policy rate, constraining the room for monetary-policy operations. If interest is paid at a relatively high rate, households will hold more and correspondingly reduce bank deposits. Commercial banks must then adjust deposit rates to cope with the liability-side change, which in turn affects credit provision and the money multiplier. The Riksbank's technical discussion of interest-bearing rules provides an important reference for examining how an interest-bearing regime affects the money multiplier. Notably, the Riksbank has consistently framed the e-krona as a supplementary means of preserving a risk-free central-bank liability against the backdrop of cash disappearance, rather than as a competitive asset that replaces commercial-bank deposits. Under the proposed phased plan, the first phase offers non-interest-bearing basic functions, and only the second phase considers introducing interest-bearing services. The rate is conceived as linked to the policy rate and significantly below deposit rates. This orientation indicates that the actual impact of an interest-bearing scheme on the money multiplier hinges critically on the relative position of the interest rate vis-a-vis deposit rates and on the pace of phased implementation.

3.3 The Bahamas' Sand Dollar: Cash Substitution and Tiered Wallets

Launched officially in 2020, the Sand Dollar is among the world's earliest deployed retail CBDCs. Its design aims to digitalize the payment system and broaden financial-service coverage, addressing the uneven distribution of financial-institution branches and inadequate financial accessibility in an archipelago nation. It pays no interest, functions primarily as a payment instrument, and adopts a tiered-wallet system that sets differentiated balance and transaction limits for individuals versus businesses and for ordinary versus higher-tier wallets. Research shows that holding caps can limit residents' large-scale conversion of bank deposits into CBDC and mitigate commercial banks' disintermediation and solvency risks [13]. This finding confirms the practical effect of tiered limits in curbing deposit disintermediation. Its substitution target is concentrated on cash, so the money-multiplier change mainly manifests as a change in the cash leakage ratio. Yet the Sand Dollar's circulation scale has remained low for a long time, and public willingness to use it has been insufficient. This reflects that when cash remains freely usable and bank deposits are unconstrained, pure payment substitution struggles to expand spontaneously. This experience suggests that although the multiplier effect of a cash-substitution scheme is mild, its actual outcome also depends on the network economies of the payment system and user-incentive design, rather than on the institutional text itself.

3.4 Comparison of Scheme Differences

The three schemes present a contrast between non-interest-bearing and interest-bearing orientations in their interest rules. Both the e-CNY and the Sand Dollar adhere to non-interest-bearing designs, whereas the e-krona explicitly discusses an interest-bearing option. In terms of substitution target, both the e-CNY and the Sand Dollar primarily target cash substitution, with limited direct impact on the deposit system, while the e-krona attracts more attention because of the technical possibility of deposit substitution. Regarding holding constraints, the first two both adopt tiered wallets and limit systems, curbing deposit disintermediation by setting holding caps. From the banking-liability perspective, cash substitution exerts a mild shock on the money multiplier, whereas deposit conversion brings a significant shock. Interest rules determine the incentive to convert. Holding constraints determine the upper bound of conversion scale. The operational architecture determines the degree of shock to the credit-intermediation chain. The institutional-design differences among the three schemes provide a concrete analytical basis for comparing money-multiplier changes under different institutional arrangements. In terms of sample representativeness, the three schemes cover cases with markedly different levels of economic development, financial structure, and cash-usage intensity. China is a large economy with massive cash circulation and a bank-dominated financing channel. Sweden is a developed economy with extremely low cash usage and highly prevalent non-cash payments. The Bahamas is a small open economy with sparse financial-institution branches and limited financial accessibility. This heterogeneity makes the three design combinations correspond respectively to different intervals of multiplier shock ranging from weak to strong, enhancing the external validity of the comparative conclusions.

4. Comparative Analysis of Money-Multiplier Changes under Different Institutional Arrangements

4.1 Effects of Interest-Bearing Rules

A non-interest-bearing design confines a CBDC's competitive sphere to payment scenarios and avoids eroding commercial banks' core liabilities. Both the e-CNY and the Sand Dollar embody this logic. Yet Armelius et al. [12] note that a non-interest-bearing design also sets a de facto zero lower bound on the policy rate, which gives it a dual attribute. The net effect of an interest-bearing arrangement is not unidirectionally negative. A CBDC interest rate instrument can widen the room for policy rate cuts and ease the constraints that negative rate policy imposes on bank credit [3]. When the rate is set low, the savings substitution effect is weak while the policy tool function is brought into play. When the rate is too high, deposit disintermediation dominates and the money multiplier contracts. Its role must therefore be judged in conjunction with the banking sector's competitive structure [5, 7]. From the perspective of parameter transmission, introducing an interest-bearing CBDC changes the public's opportunity-cost structure of holding money. Portfolio reallocation simultaneously pushes up the cash leakage ratio and the time deposit ratio. As both parameters rise in the same direction, the contraction direction of the money multiplier becomes more certain. By contrast, a non-interest-bearing design acts mainly on the cash leakage ratio and, constrained by payment convenience and conversion costs, yields relatively mild multiplier changes. This means that the choice between interest-bearing and non-interest-bearing designs is essentially a trade-off between expanding the room for monetary-policy operations and maintaining multiplier stability.

4.2 Effects of Operational Architecture and Holding Constraints

Under a single-tier operational architecture, the central bank issues CBDC directly to the public, and commercial banks are excluded from credit intermediation. This severs the transmission chain from the monetary base to broad money. Under a two-tier architecture, the central bank places CBDC with commercial banks, which then exchange it with the public. Commercial banks can thus ease the liability-side shock through liquidity management and portfolio adjustment, keeping money-multiplier fluctuations within a controllable range. The e-CNY's two-tier design embodies this logic. Balance-sheet framework analysis also shows that deposit outflows weaken banks' money-creation function, and that a rising reserve ratio amplifies the downward pressure on the money multiplier [1]. Digital currency exerts a positive effect in the financing process by reducing real financial frictions, partly offsetting the negative shock of deposit substitution [14]. On holding constraints, tiered wallets and holding caps restrict large-scale deposit conversion [13]. Taken

together, the combination of non-interest-bearing design, cash substitution, two-tier operation, and tiered limits can minimize the money-multiplier shock while preserving commercial banks' credit-intermediation function. By contrast, combinations of interest-bearing design, deposit substitution, or the absence of holding constraints may amplify the risks of disintermediation and multiplier contraction. In addition, the timing of shocks and the immediacy of transmission matter equally. If deposit conversion occurs en masse during a period of market stress, the reserve ratio will jump rapidly and the money multiplier will plummet, potentially triggering further conversion motives through expectation channels. Holding caps must therefore be coordinated with central-bank liquidity support tools to block the self-reinforcing process of deposit disintermediation in extreme circumstances and avoid a nonlinear contraction of the multiplier.

5. Practical Challenges and Future Prospects

A CBDC relies on a digital ledger to record transaction information. Its traceability improves the efficiency of anti-money-laundering and counter-terrorism-financing efforts. However, it also poses a potential threat to public data privacy. Privacy-protection design indirectly affects the scale of deposit disintermediation and money-multiplier stability by influencing the public's willingness to hold CBDC. On financial stability, a CBDC provides a safer-asset channel more convenient than cash. During periods of financial stress, the speed and scale at which the public converts bank deposits into CBDC en masse may far exceed those of traditional cash runs [9]. Holding caps, tiered interest, and liquidity-support arrangements are therefore indispensable. At the international level, digital currencies tied to large platform ecosystems may give rise to cross-border digital-currency areas. Economies that are highly integrated socially or digitally face the risk of digital dollarization [15]. This would weaken the independence of domestic monetary policy and make the domestic money multiplier more dependent on external monetary conditions. The cross-border application of the e-CNY must balance the maintenance of monetary sovereignty against the steady advancement of RMB internationalization. Looking ahead, monetary authorities need to seek a more nuanced balance between curbing deposit disintermediation and expanding monetary-policy tools. With respect to the money multiplier, institutional heterogeneity, privacy design, and international competition should be incorporated into a unified framework. Cross-country empirical data should be used to test the direction and magnitude of money-multiplier changes under different institutional arrangements. This will provide more solid empirical evidence for institutional optimization.

6. Conclusions and Policy Recommendations

6.1 Research Conclusions

This paper constructs an institutional analysis framework along three dimensions, namely interest-bearing rules, operational architecture, and the substitution target and holding constraints. Based on a comparison of three representative schemes, it draws several conclusions. Interest-bearing rules determine whether a CBDC possesses saving attributes and the intensity of its substitution for deposits. The operational architecture determines commercial banks' intermediary position in the credit-creation chain and the completeness of the multiplier-amplification mechanism. The substitution target and holding constraints determine the potential scale of deposit disintermediation. A non-interest-bearing design positioned as a cash substitute minimizes the shock to the money multiplier. An interest-bearing model combined with high holding limits strengthens the deposit-substitution effect and triggers financial disintermediation risk. The two-tier operational architecture is an important institutional safeguard against shocks.

6.2 Policy Recommendations

First, maintain the non-interest-bearing positioning and clarify the e-CNY's role as a cash supplement. Even if an interest-bearing function is explored, the rate should be set significantly below deposit rates and be accompanied by holding caps. Second, preserve the two-tier operating model and dynamically adjust reserve policy and liquidity-provision instruments to avoid large fluctuations in banks' loanable funds. Third, dynamically adjust individual wallet balance limits according to economic and financial conditions. Holding caps should be moderately tightened during periods of financial stress and moderately relaxed when markets are stable. Fourth, improve the statistical monitoring system by incorporating digital-currency balances into

the dynamic monitoring framework for monetary statistics and financial stability. This will help promptly identify early signals of deposit disintermediation and money-multiplier anomalies and provide data support for the preemptive fine-tuning of monetary policy. Working in concert, these institutional arrangements can give full play to the e-CNY's positive role in improving payment efficiency and promoting financial inclusion while safeguarding the soundness of the financial system.

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Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

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