The Monetary Transmission Effects of Central Bank Digital Currency (CBDC) in Hungary: A Simplified DSGE Simulation

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ABSTRACT: The paper examines how the introduction of a moderate, interest-neutral (policy-rate-remunerated) central bank digital currency (CBDC) modifies the short-run transmission of monetary policy in Hungary's 2025 macroeconomic environment. It extends a baseline New Keynesian DSGE model with a CBDC, in which household savings are split between deposits and CBDC while bank lending is tied to deposits, so deposit substitution can weaken intermediation. Following calibration, simulations and impulse responses suggest that rule-based stabilisation largely remains intact, but the responses of real variables are more muted and adjustment may be slower.
KEYWORDS: central bank digital currency, monetary transmission, dynamic stochastic general equilibrium model, bank intermediation, financial stability.
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Introduction

Central bank digital currency (CBDC) represents the next potential evolutionary step in the monetary system. It is a direct, digitally accessible liability of the central bank, which—like cash—is safe, yet programmable, and may stimulate innovation in the payments ecosystem. The literature, however, emphasises that CBDC may compete with commercial bank deposits, which could carry disintermediation risk and alter the channels of monetary transmission.

The aim of this paper is to quantify and interpret the extent to which the introduction of a moderate, interest-neutral CBDC (remunerated at the policy rate) alters the short-run transmission mechanism of monetary policy

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in Hungary's 2025 macroeconomic environment. The analysis is based on a simplified DSGE model that augments the baseline New Keynesian structure (household–firm–central bank) with a portfolio extension.

Objective

The objective of this paper is to quantify and interpret the extent to which, and through what channels, the introduction of a moderate, interest-neutral CBDC (remunerated at the policy rate) modifies the short-run transmission of monetary policy in Hungary's 2025 macroeconomic environment, by means of comparative simulation and impulse response analysis of a simplified New Keynesian DSGE model in its baseline and CBDC-extended variants.

Methodology

Overview of CBDC

Central bank digital currency is a form of money issued by the central bank that exists in digital form and, like cash, represents a liability of the central bank. The defining characteristic of CBDC is therefore that—unlike commercial bank deposits and private-sector electronic money solutions—it constitutes a risk-free central bank money claim that can be used to settle transactions, and whose introduction can align the central bank component of the monetary system with the payment needs of the digital economy (Bank for International Settlements, 2020).

CBDC can be understood in relation to the three classical pillars of the monetary system.

- Cash: anonymity, immediate finality, central bank liability. CBDC seeks to reproduce some of these properties in a digital environment (Bank for International Settlements, 2020).
- Commercial bank deposit: a widely used electronic form of money, but subject to credit and liquidity risks, bank intermediation, and a regulatory safety net. CBDC, by contrast, is a direct central bank claim, and can therefore in principle reduce the risk components of monetary transactions (Adrian and Mancini-Griffoli, 2019).
- Crypto-assets/stablecoins: typically privately issued, carrying exchange rate and/or collateral risk, with differing legal status. The distinguishing feature of CBDC is its legal and institutional embeddedness, linked to the central bank's monetary sovereignty, payment infrastructure, and supervisory environment (Auer and Böhme, 2020).

Main Types of CBDC

Based on the academic literature and international institutional surveys, two fundamental types of CBDC can be distinguished.

- Retail CBDC: the central bank's digital money, which can be used by households and firms, functioning as the digital equivalent of cash. Typical objectives include improving the efficiency of payment systems, increasing financial inclusion, and modernising the infrastructure associated with digital payments (Mancini-Griffoli et al., 2018; Kiff, Alwazir and Davidovic, 2020).
- Wholesale CBDC: digital central bank money designed primarily for transactions between financial institutions (interbank settlements, securities clearing), with the primary goal of increasing the efficiency of payment and settlement systems and reducing liquidity risk (Bank for International Settlements, 2020).

The choice between the two types is significant: retail CBDC can directly affect households' money-holding decisions and the banking system's funding base, while wholesale CBDC is more likely to transform the functioning of financial infrastructure and interbank markets.

The introduction of CBDC is not a binary decision—it is not simply a yes-or-no choice—but rather a series of design decisions. These design choices are as follows.

- Token-based or account-based approach
- Token-based CBDC follows the logic of "digital cash": users hold and transfer digital units (tokens). Its advantage is that it may be technically closer to cash and can in principle support stronger privacy solutions, though compliance with anti-money laundering requirements and the handling of misuse present significant challenges (Anthony, 2023). Account-based CBDC, by contrast, involves a structure in which users hold digital central bank money linked to an identified account; this can provide greater transparency, but anonymity is more limited (Andolfatto, 2021).
- Direct (single-tier) or intermediated (two-tier) distribution, hybrid and synthetic solutions
- Distribution—that is, who manages the end-user relationship and the wallet—is a key question. In intermediated (two-tier) models, commercial banks and payment service providers often retain their client-facing roles, which can reduce implementation friction but also adds systemic complexity (Mancini-Griffoli et al., 2018). A significant portion of the literature examines hybrid and "minimally invasive" solutions, where CBDC remains a central bank claim but front-end services are provided by the private sector, in order to mitigate an abrupt contraction of bank intermediation (Auer and Böhme, 2021).
- Remuneration and holding limits

  Among the most important design parameters of CBDC is whether it bears interest and, if so, how. An interest-bearing CBDC can strengthen monetary transmission by directly influencing households' savings and portfolio decisions, but it also carries financial stability risks due to competition with bank deposits. Tiered remuneration (for example, a lower/neutral rate up to a baseline amount and a different rate above that threshold) is a well-established proposal in the literature for mitigating the risk of bank funding outflows (Bindseil, 2019).

The introduction of CBDC in the monetary system simultaneously represents an infrastructural innovation and a macro-financial shock. The modernisation of payments and settlement can yield faster, cheaper, and potentially more resilient payment solutions (Auer and Böhme, 2020; Bank of England, 2020). Retail CBDC is often positioned as a tool for broadening access to financial services; however, the "digital divide" and inequalities in user capabilities may limit its impact (Kiff, Alwazir and Davidovic, 2020).

From the perspective of monetary transmission and the interest rate channel, an interest-bearing CBDC would allow the central bank to influence the return on retail money holdings more directly—this could serve as a new instrument in the monetary policy toolkit, particularly if the decline in cash usage constrains the effective lower bound on interest rates (Bordo and Levin, 2017; Bindseil, 2019). Regarding bank intermediation and financial stability, retail CBDC could potentially reduce the stock of bank deposits, which would affect banks' lending capacity and financial stability more broadly. The literature therefore emphasises design principles that safeguard financial stability (e.g. remuneration rules, convertibility limits, holding caps) (Kumhof and Noone, 2021; Auer and Böhme, 2021).

For all these reasons, CBDC is not merely a "digital means of payment" but a reform affecting the institutional architecture of the monetary system, as it simultaneously impinges on payment infrastructure, monetary policy transmission, and the funding and risk structure of the banking system (Bank for International Settlements, 2020; Adrian and Mancini-Griffoli, 2019).

Overview of the DSGE Model

Dynamic stochastic general equilibrium (DSGE) models provide the standard quantitative framework of modern macroeconomics, in which the intertemporal optimisation problems of economic agents (households, firms, the government, and—where necessary—the financial intermediation sector) jointly determine the co-movement of macroeconomic time series and their responses to various shocks, intertemporal optimisation. The approach is "dynamic" because it explicitly addresses the intertemporal dimension of decisions, “stochastic” because the economy is influenced by exogenous random shocks (e.g. technology, demand, cost-side, monetary, financial), and “general equilibrium” because it simultaneously ensures the interconnectedness of markets and the satisfaction of budget constraints (Schorfheide, 2011; Fernández-Villaverde, 2010). market-clearing conditionsDSGE models typically start from the household side, where the representative (or heterogeneous) household maximises utility through consumption–savings and labour supply decisions. On the firm side, decisions on production and pricing (and wage-setting) appear, while under monetary policy, the central bank sets the nominal interest rate according to a rule (e.g. a Taylor rule) or an optimal policy. Market clearing closes the model (goods market, labour market, money/asset market equations). In modern (New Keynesian) DSGE variants, nominal rigidities (e.g. Calvo pricing, wage stickiness) and real frictions (e.g. investment adjustment costs, habit formation) allow the model to approximate empirically the observed business cycle properties and the dynamic effects of monetary shocks (Christiano, Eichenbaum and Evans, 2005; Smets and Wouters, 2007).

In practice, DSGE models are often solved using log-linearisation and solution algorithms under rational expectations, after which unknown parameters areestimated or calibrated (typically using Bayesian methods). The advantage of the Bayesian framework is that prior information on structural parameters and the information content of macro data can be combined in a single coherent procedure, while the model can be compared with alternative statistical benchmarks (Smets and Wouters, 2007; Fernández-Villaverde, 2010).market equilibrium closes the model.

Let us examine why the DSGE model is appropriate for the present scenario and analysis.

- Structural, causal interpretability and potential for counterfactual analysis
  In DSGE models, parameters and equations directly represent economic mechanisms (preferences, technology, price and wage rigidities, financial frictions). This makes the model suitable for addressing questions where causal claims and the consequences of policy changes are paramount (Woodford, 2003; Galí, 2015).
- Handling of expectations and intertemporal consistency.
  In the monetary policy context, the role of expectations is crucial. The decisions of households and firms are based not only on current conditions but also on expectations about the future. The DSGE framework explicitly incorporates this intertemporal channel, making it possible to interpret the effects of interest rate policy and central bank communication (Woodford, 2003; Galí, 2015).
- Internal consistency and budget constraints
  The “general equilibrium” nature of the model ensures that prices, quantities, incomes, and asset stocks evolve jointly and consistently with one another. This is particularly relevant when new institutional elements

are introduced into the model: the added channel must be compatible with the constraints of the broader economic environment.

- Empirical fit and forecasting
  Estimated DSGE models not only provide a theoretical "narrative" but, when fitted to time series, are capable of shock decomposition and can be applied in forecasting practice. According to the literature, the DSGE framework is particularly powerful when combined with complementary procedures or appropriate prior structures for forecasting purposes (Del Negro and Schorfheide, 2013).
- Applicability in central banking
  In monetary policy analysis, the strength of DSGE models lies in linking the dynamics of the real and nominal sides of the economy within a single framework, and in enabling the quantitative identification of the transmission channels of policy (Woodford, 2003; Smets and Wouters, 2007).
  One of the fundamental results of models examining the macroeconomic effects of CBDC is that portfolio reallocation driven by incentive differentials can affect banks' funding costs, lending activity, and ultimately investment and output. Barrdear and Kumhof (2016) highlight the longer-run welfare and output effects of CBDC within a structural framework. Keister (2023) emphasises the policy trade-off between deposit substitution and real economic effects. The IMF (2023; 2024) reviews point out that the channels of transmission depend on CBDC design (remuneration, caps, two-tier model).

Baseline Model (without CBDC)

The baseline model is a standard, micro-founded DSGE framework. The representative household maximises intertemporal utility as a function of consumption and labour supply (leisure). In the budget constraint, the household holds bank deposits whose nominal return is tied to the policy rate set by the central bank. Firms' production function is of the Cobb-Douglas type, with output influenced by an exogenous technology level (A_t). Monetary policy responds to deviations of inflation and the output gap from their targets according to a Taylor rule.

- Key equations:
- Household: max $E_0 \Sigma_t \beta^t [u(C_t) - v(N_t)]$
- Budget constraint: $C_t + D_t = (1+R_{t-1})D_{t-1} + W_t N_t + \Pi_t$
- Euler equation: $1 = \beta E_t[(1+R_t) u'(C_{t+1})/u'(C_t)]$
- Production: $Y_t = A_t \cdot N_t^{\alpha}$
- Technology shock: $\ln A_t = \rho \ln A_{t-1} + \varepsilon_t$
- Taylor rule: $R_t = R^* + \phi\pi(\pi_t - \pi^*) + \phi y(Y_t - Y^*)$

CBDC Extension

- In the extended model, the household splits its savings between two assets: bank deposits (D_t) and CBDC ($CBDC_t$). The portfolio allocation is described by the displacement factor (θ). In the baseline scenario examined, the CBDC rate equals the central bank policy rate ($R(CBDC)_t = R_t$), so portfolio choice is influenced not by a yield differential but by liquidity/convenience preferences. As an explicit representation of bank intermediation, we assume that bank lending is a function of the deposit stock ($L_t = \lambda D_t$), so deposit displacement also reduces lending capacity.
- Portfolio: $D_t = (1-\theta)M_t$, $CBDC_t = \theta M_t$
- Lending: $L_t = \lambda D_t$
- CBDC rate: $R(CBDC)_t = R_t$ (baseline)

- The framework also allows for the central bank to use the CBDC rate as an independent instrument ($R(CBDC)_t \neq R_t$); however, the present paper focuses on the interest-parity, interest-neutral scenario.

Calibration and Simulation Assumptions

The calibration is based on macroeconomic data for the Hungarian economy in 2025, supplemented by standard parameters from the literature. The magnitude of the technology shock is set at 1%, decaying with a persistence of $\rho = 0.6$. The introduction of CBDC is interpreted, by analogy with the baseline shock, as a technological innovation that materialises through an improvement in payment efficiency.

Table 1. Main calibration parameters of the model (2025).

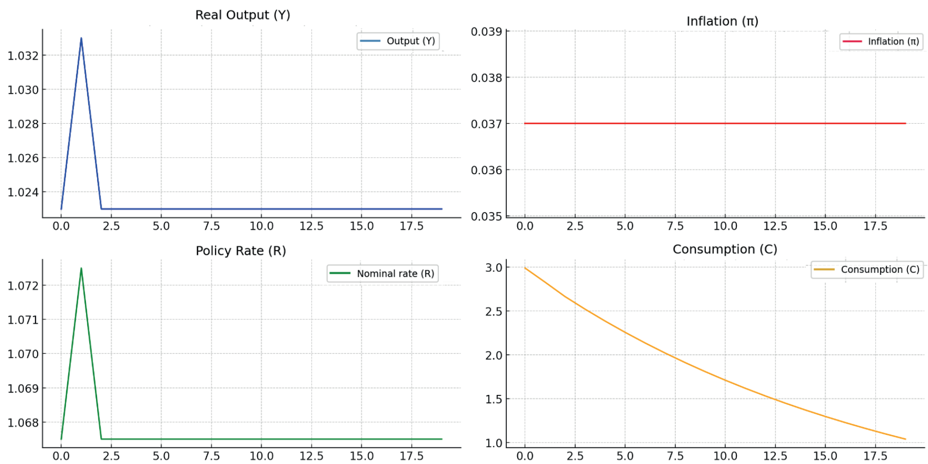
Parameter/variable	Notation	Value (2025)	Source
Discount rate	β	0.99	Galí (2008)
Inflation	π	0.037	MNB (2025)
Policy rate	R*	0.0675	MNB (2025)
Taylor weights	ϕπ, ϕy	1.5 ; 0.5	Taylor (1993)
Potential growth (scale)	Y*	1.023	MNB (2025)
Displacement factor	θ	0.25	Simulation assumption
Technology shock persistence	ρ	0.6	Simulation assumption

Results

Baseline Model – Impulse Responses (without CBDC)

Figure 1 illustrates the impulse responses of the baseline model to a positive technology shock. Output rises in the short run, the central bank raises the policy rate in accordance with the Taylor rule, and this moderates consumption through intertemporal substitution. In the implementation presented, inflation is exogenously fixed at its 2025 value and therefore does not respond endogenously to the shock; relaxing this assumption is the natural direction for the next planned extension of the model for publication.

Figure 1. Simulation of the baseline monetary DSGE model (without CBDC).

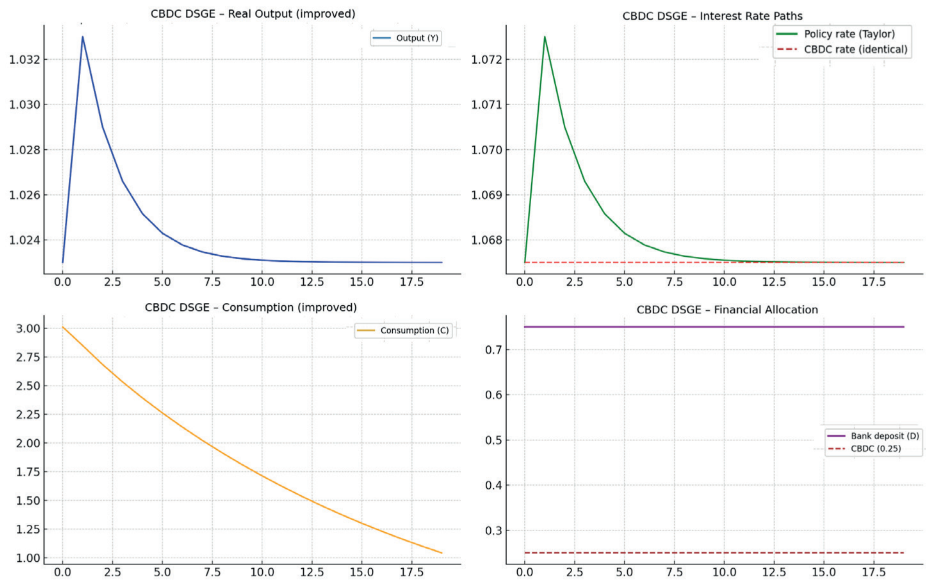


Source: own elaboration.

CBDC Model – Impulse Responses and Financial Allocation

Figure 2 shows the results of the CBDC-extended model. In the financial allocation, the share of bank deposits is 0.75, while the share of CBDC is 0.25. In the baseline, the CBDC rate equals the central bank policy rate, so the yield differential provides no additional incentive for reallocation. The responses of output and consumption follow the baseline logic, but the partial weakening of bank intermediation moderates the amplitude of real variables, while the stabilising role of the interest rate path is maintained.

Figure 2. CBDC-based monetary DSGE model with technology shock.



Source: own elaboration.

Summary Comparison

The paths presented illustrate the responses to the technology shock over a 20-period horizon. An important methodological note is that the present implementation displays variables in levels and the consumption path is partly of a convergencenature (from the initialisation towards the long-run value), so the impulse responseintuition is best interpreted primarily on the basis of output and interest rate dynamics.

In the baseline model, the positive technology shock causes a short-run increase in real output. In the simulation figure, output jumps from its initial level (approx. Y≈1.023) to approximately Y≈1.033 within one period, corresponding to a peak response of approximately ~1%. Given the transitory nature of the shock and the simplified dynamics, output returns close to its initial level in the following period. In line with the rise in output, the policy rate tightens: the nominal rate rises from its initial value (approx. R≈1.0675 ≈ 6.75%) to R≈1.0725 in the short run (an increase of approximately ~0.5 percentage points). The rapid reversion of the interest rate suggests that (in the baselineimplementation) the shock effect and/or the monetary response is not persistent, so transmission operates mainly through the immediate interest rate channel . The consumption path declines gradually over the horizon (from approx. 3.0 to ~1.05), a pattern that in this implementation is driven predominantly by the simplified adjustment rules applied in the model and the level-basedrepresentation convergence rather than by the shock itself. The direction of monetary tightening is nonetheless consistent with standard New Keynesian intuition: at a higher interest rate, households reduce current consumption (intertemporal substitution), which dampens the demand side. In the baseline model, inflation is not endogenous: the path is practically constant ($\pi \approx 3.7\%$). As a result, the monetary policy response in the present results is based primarily on changes in output/activity, and the price adjustment mechanism of the Phillips curve is absent. The message from the baseline model results is that a technology improvement raises activity in the short run, while the central bank—following the rule—stabilises through an interest rate increase. The dynamics here unwind quickly, partly as a result of the simplifications (limited state variables, fixed inflation).curve price adjustment mechanism. The message of the baseline model is that a technology improvement raises activity in the short run, while the central bank—following the rule—stabilises through an interest rate increase.

In the extension, households' financial portfolio consists of two components: bank deposits and CBDC. In the baseline, portfolioshares are exogenously fixed: bank deposits 0.75 and CBDC 0.25. This setting "moderate displacement" (partial disintermediation) scenario. The peak of the output response is similar to the baselinemodel (approx. $Y \approx 1.033$), but the decay is longer and gradual: output remains above its initial level for several periods before converging back near its starting point around periods 8–12. This pattern is reinforced by the persistent shock process (AR(1) nature, $\rho > 0$) employed in the extended simulation and the gradual normalisation of the monetary response. The policy rate rises following the shock, then gradually declines back towards its initial level. In the figure, the CBDC rate appears as a separate path; in the present baseline, the CBDCrate quasi-fixed (anchored to the initial level), so in the periods following the shock a transitory divergence (gap) may arise between the policy rate and the CBDC return. If the CBDC rate does not follow the policy rate, then in principle a yield differential may emerge that could incentivise households to reallocate their portfolios (from deposits to CBDC or vice versa). In the present simulation, however, financial allocation is described by fixed shares, so the yield gap reallocate their portfolios (from deposits to CBDC or vice versa). In the present simulation, however, the financial allocation is governed by fixed ratios, so the yield gapdoes not translate intoendogenous deposit outflows. According to the financial allocation panel, the ratio of bank deposits to CBDC remains constant throughout the horizon (0.75 vs 0.25). This means that in the model, the banking system'sfunding base is already lower in the initial state than in the baseline model. In a more complete banking block (lending, balance sheetspread), the smaller deposit base may reduce lending capacity, raise the loan interest ratespread, and dampen investment/output responses. In the present simplified setting, this channel is not yet endogenous, but the fixed CBDCshare can be interpreted as a reduction in the “effectiveness” of bank intermediation. The consumption path in the CBDCmodel also shows a similar convergence. The key message here is that CBDC in its present form does not generate an independent, strong demand “boom” or “bust”; the dominant dynamics remain the combination of the shock and the monetary policy response.

The peak output responses in the two models are nearly identical, but in the CBDCmodel the dynamics are more protracted. In the narrative of the paper, this can be expressed as: the CBDCextension (under the present parameterisation) does not fundamentally alter the direction of the shock and the stabilising role of monetary policy. The critical question from the perspective of monetary transmission is whether the CBDC rate follows the the policy rate. For a rate-tracking CBDC, the portfolioreallocation yield motivation is smaller; for a fixed or capped CBDCrate, however, changes in the policy rate may temporarily open a yield gap which—under an endogenous portfolio—would exert pressure towards depositwithdrawal/reallocation. The 25% CBDCshare can be interpreted as partial substitution of bank funding. In a more complete model, this channel can contribute—through the credit supply and financing costs—to modifying the responses of real variables. The present chapter’s results *foreshadow* this logic, but the explicit incorporation of endogenous credit/spread dynamics is the next extension step of the paper.

Policy Implications and Model Limitations

The main limitations of the model are as follows:

- the exogenous treatment of inflation in the present implementation,
- the highly reduced description of the banking sector ($L_t = \lambda D_t$), without capital constraints, risk, or bank pricing,
- the representation of the CBDC introduction as a “technology shock”, which captures the improvement in payment efficiency but does not explicitly model the endogenous change in transaction costs and money demand.

In the present implementation, inflation is essentially fixed, so the key element of standard New Keynesian transmission is absent: how, under nominal rigidities (e.g. Calvo pricing), the demand/output gap is translated into inflation dynamics (Woodford, 2003; Galí, 2015). A consequence is that the central bank’s interest rate response relies on output, while the inflation channel and the role of inflation expectations can only be interpreted in a limited way. The interest rate rule (Taylor-type) provides a useful foundation, but without endogenousinflation the interpretation of the rule is partial, and the role of the real/natural rate (r*) cannot be explored in depth (Woodford, 2003; Galí, 2015).

In the extended model, the ratio of CBDC to bank deposits is fixed (e.g. 0.25 and 0.75). As a result, yield differentials (between the policy rate and the CBDC rate) do not trigger endogenous deposit withdrawal or reallocation. This assumption severely limits the examination of one of CBDC's most important channels: the effect of competition between deposits and CBDC on banks' funding costs, lending, and ultimately on investment and output (Keister and Sanches, 2023; Niepelt, 2024).

The intermediation role of the banking system—especially crisis-period dynamics—is typically described by balance sheet constraints, external financing premiums, credit spreads, and endogenous risk-taking. Without these, the real economic effect of "displacement" can only be indicated qualitatively, not quantified. The literature offers several established models for this purpose, such as the financial accelerator (Bernanke, Gertler and Gilchrist, 1999) or intermediation balance-sheet-constrained frameworks (Gertler and Karadi, 2011).

One policy risk of CBDC is the possibility of a rapid "digital bank run". Examining this requires elements such as deposit liquidity shocks, bank liquidity management, potentially an interbank market, and the coordination problem among depositors (Diamond and Dybvig, 1983). The CBDC design literature explicitly emphasises that design choices can mitigate this risk (Bindseil, 2020; Kumhof and Noone, 2018).

The calibration is fast and transparent, but policy conclusions may be highly sensitive to the chosen parameters (Fernández-Villaverde, 2010). In CBDC scenarios, for example, substitution elasticities, the CBDC rate rule, bank spreads, and shock persistence can be decisive.

A central challenge in DSGE estimation is that several parameters are weakly or partially identified, which can result in wide-interval scenarios, unstable estimates, or misleading policy implications (Canova and Sala, 2009; Iskrev, 2010).

Hungary is a small, open economy in which the exchange rate, external demand, and risk premium channels are typically of central importance. Both the introduction of CBDC and monetary transmission may behave differently in an open economy, particularly due to foreign exchange market and capital market linkages (Galí and Monacelli, 2005).

These gaps can be addressed in a subsequent paper with an extended New Keynesian and bank balance sheet framework.

Conclusions

This paper finds, using a simplified DSGE framework calibrated to 2025 Hungarian macroeconomic data, that the introduction of a moderate, interest-neutral CBDC does not in itself materially impair the effectiveness of rule-based monetary policy. However, the partial displacement of bank deposits does moderate the multiplier effect operating through bank intermediation, which may manifest as dampened real economic responses. The most important practical message is that CBDC design (remuneration, caps, two-tier introduction) is crucial for managing transmission and financial stability risks. The effectiveness of monetary policy. The partial displacement of bank deposits, however, moderates the multiplier effect operating through bank intermediation, which may manifest as dampened real economic responses.

In the DSGE framework presented, the technology shock increases output in the short run in both the baseline and the CBDC-extended variant, while monetary policy stabilises through a rule-based interest rate increase. The main difference between the two specifications lies not in the directions but in the dynamics: in the CBDC variant, the output response is more protracted and the normalisation of the interest rate path is more gradual. This is consistent with the interpretation that the modification of financial structure (the introduction of CBDC in the portfolio) and shock persistence jointly shape the time profile of transmission, while the stabilisation logic is preserved.

The scientific message of the model results is therefore that, under moderate, interest-neutral CBDC penetration, the effectiveness of monetary policy is not materially impaired, although the pace of real economic adjustment may change. The validity of the conclusions is tied to the limitations of the specification: the exogenous fixing of CBDC demand and the absence of endogenous inflation/financial intermediation mean that the "displacement" and stability channels can only be quantified to a limited extent. Accordingly, the most important next steps are the incorporation of endogenous portfolio choice, the bank balance sheet/credit channel, and the inflation block, so that the relationship between CBDC design and monetary transmission can be tested more rigorously against empirical data.

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