

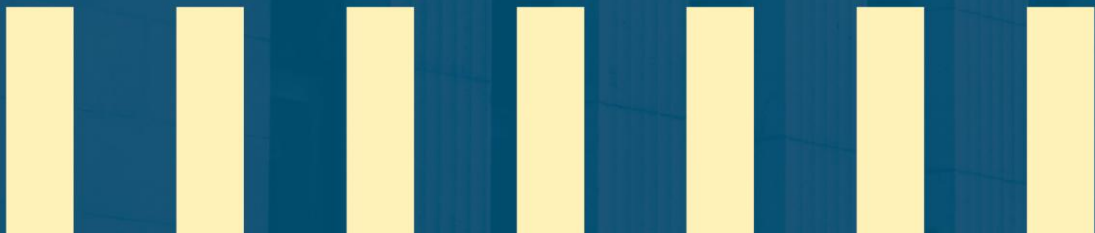
The Impact of Potential Retail Central Bank Digital Currency on the Canadian Financial System During a Severe Recession

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DOI: <https://doi.org/10.34989/sap-2026-30> | ISSN 3110-9195

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Acknowledgements

I would like to acknowledge the immense help of Ruben Hipp, Gabriel Bruneau, Florent Samson, Adi Mordel, Vatya Kishore, David Cimon, Andrew Usher, Heng Chen, Walter Engert, Oleksandr Shcherbakov, Scott Hendry, Francisco Rivadeneyra, Janet Jiang, Jonathan Chiu and Isabel Zheng. The views expressed in this work belong to the author and do not represent the official views of the Bank of Canada.

Abstract

This policy note examines how a non-interest-bearing retail central bank digital currency (CBDC) could affect the financial stability of Canada's systemically important banks during a severe recession. Stress test results show that the banks remain resilient, maintaining key regulatory ratios even under high CBDC demand. To manage funding outflows, banks scale back balance sheet growth and replace some lost deposits with alternative funding. Profitability stays strong overall, though short-term volatility may occur. To reduce potential risks, the note recommends a gradual CBDC rollout with holding limits, well-timed capital buffer adjustments, early communication of regulatory changes, and coordination with central bank balance sheet policies.

Research themes: Models and tools - Economic models; Structural challenges - Digitalization and productivity; Financial system - Financial stability and systemic risk; Money and payments - Digital assets and fintech

JEL codes: E58, E44, G21, G28, E61, G01

Résumé

Cette note examine la façon dont une monnaie numérique de banque centrale (MNBC) de détail ne portant pas intérêt pourrait influencer sur la stabilité financière des banques d'importance systémique du Canada en période de profonde récession. Les résultats du test de résistance montrent que celles-ci restent résilientes et maintiennent leurs principaux ratios réglementaires, même en cas de forte demande de MNBC. Pour gérer les sorties de fonds, les banques réduisent la croissance de leur bilan et remplacent certains dépôts perdus par d'autres sources de financement. Leur rentabilité reste élevée dans l'ensemble, malgré une possible volatilité à court terme. Pour réduire les risques potentiels, la note recommande un déploiement progressif de la MNBC avec des plafonds de détention, des ajustements opportuns des volants de fonds propres, des mises à jour de la réglementation sur la liquidité, une communication en amont des changements réglementaires et une coordination avec les politiques de bilan des banques centrales.

Codes JEL : E58, E44, G21, G28, E61, G01

1. Introduction

This note examines whether the introduction of a retail, non-interest-bearing central bank digital currency (CBDC) could exacerbate the financial vulnerabilities of Canada’s domestic systemically important banks (DSIBs) during a severe recession. It also investigates the transmission channels through which banks interact with the real economy, financial markets and the central bank in the presence of a CBDC. Based on the findings, the paper proposes a set of risk-mitigation policies.

Previous work concluded that CBDC would have limited effects on banks under normal conditions, primarily by reducing profitability.¹ These effects were more pronounced for medium-sized and small banks than for DSIBs. Building on that foundation, the current analysis shifts focus to the second component: assessing whether CBDC could amplify stress in the banking sector during economic downturns. In such periods, banks are typically exposed to prolonged, slow-moving financial shocks. These shocks may interact with CBDC-induced vulnerabilities—such as weaker profitability and increased funding instability—to create abnormal stress in bank performance. To address these potential risks, we evaluate mitigation strategies, including a phased CBDC rollout, holding limits, and adjustments to macroprudential tools such as the Domestic Stability Buffer (DSB) and the Liquidity Coverage Ratio (LCR) runoff rates. Broader implications for central bank operations and financial markets are also explored.

Our results indicate that a retail CBDC can be introduced without undermining financial stability, provided it is supported by a gradual rollout and complementary regulatory measures. Even when banks face funding outflows and pressure on profitability, their resilience can be preserved through strategic balance sheet adjustments and timely macroprudential responses. Elevated interest rates and strong initial capital positions could further cushion potential risks. The findings also emphasize the importance of aligning policy timing with adoption dynamics, as stress is most likely to emerge during the middle phase of uptake—when usage expands rapidly but institutional adjustments are still underway. More broadly, the results highlight that the financial system can adapt to structural changes like the introduction of a CBDC, especially with a policy design that anticipates behavioural responses and allows sufficient adjustment time. These findings complement the existing literature emphasizing the potential public benefits of CBDC in Canada, including improved payment efficiency, competition, resilience, and monetary sovereignty.²

The outline of this note is as follows. The description of our approach and main results are reported in section 2, including:

- the importance of stress exercises for CBDC (2.1)
- the need to align stress scenarios with the macrofinancial conditions (2.2)
- CBDC demand assumptions (2.3)

¹ See for instance [García et al. \(2020\)](#), [BIS \(2021\)](#) and [Gorelova, Lands and teNyenhuis \(2022\)](#).

² For Canadian context, see [Usher et al. \(2021\)](#) for the list of potential advantages CBDC may provide and [Liu et al. \(2024\)](#) for the design implications. For the comprehensive literature review on CBDC, see [Chapman et al. \(2023\)](#).

- modelling approach and calibration (2.4–2.7)
- numerical results on banks' funding, regulatory ratios and income (2.8–2.11)
- factors supporting DSIB resilience under stress with CBDC (2.12)

In section 3, we discuss second-round effects, including:

- reduction in lending to the real economy (3.1)
- central bank operations (3.2)
- impacts on market liquidity (3.3)

Section 4 outlines policy proposals, including:

- adjustments to CBDC design and rollout (4.1–4.2)
- revisions to banking regulation and oversight (4.3–4.5).

2. Impact of CBDC on DSIBs during a severe recession

2.1. Financial stress could occur before CBDC adoption is fully completed

A stress scenario is unlikely to happen during the initial phase of CBDC onboarding but could emerge before banks fully adjust their balance sheets.

Most likely the conditions for CBDC deployment would be carefully selected to encourage adoption, relieve pressure on the financial sector, and maintain the reputation of the central bank.³ In particular, the rollout would aim to establish the network effects ensuring that a sufficient number of users and merchants adopt CBDC simultaneously for it to become a practical medium of exchange. However, the adoption of a new payment technology is known to be a multi-year process, which makes it difficult to have certainty that a period of stress would not occur during the transition. For instance, in Canada:

- The share of contactless credit and debit cards kept increasing for more than a decade after 2006–08 and accelerated with the pandemic.⁴ That share has now stabilized in usage frequency.
- Prepaid cards grew in both volume and value for five years from 2016 and stagnated only during the pandemic.⁵
- The share of online payments as a method of payment plateaued in 2021, which suggests/indicates an adoption process of roughly 20 years.
- The migration of payments to chip technology began in the late 2000s, and within five years all credit cards in Canada had chip technology.⁶

Although government-facilitated innovations are typically more rapid than industry-led ones because of their broader coverage, publicity and reputation (e.g., PIX in Brazil, Sand Dollar in the Bahamas), it's likely that **CBDC adoption would still take a few years.**⁷

³ See [G7 Finance Ministers and Central Bank Governors \(2021\)](#).

⁴ See [Felt \(2020\)](#) and [Henry, Shimoda and Zhu \(2022\)](#).

⁵ See [Yun and Paturi \(2021\)](#) and [Henry et al. \(2022\)](#).

⁶ See [Chen, Felt and Huynh \(2017\)](#).

⁷ Government-run payment innovations may still lack immediate wide outreach. For instance, [Alvarez et al. \(2023\)](#) document that in the case of SINPE, an electronic peer-to-peer payment app developed by the Central Bank of Costa Rica, only 5% of adults were informed about the launch of SINPE two years into the adoption process, while almost all adults were informed about the technology within the first seven years.

In comparison, recessions in Canada occur approximately once every decade, making financial stress likely to emerge within five years after the deployment of a CBDC has started.⁸

Moreover, the diffusion of payment innovations often lacks a clear horizon and follows an S-curve pattern with a slow start and low engagement of payment users at the early stages of innovation, a turning point when a critical mass of adopters join in the middle, and widespread adoption once the technology becomes more popular and thus less costly.⁹ This S-curve pattern creates the possibility of a **recession occurring at the active (middle) phase of CBDC adoption** regardless of selective timing for CBDC deployment.

Despite the likelihood of stress occurring during the CBDC deployment, it is **unlikely that such stress would materialize and damage DSIBs**. In the past, DSIBs have remained profitable, well capitalized, liquid, and growing despite severe recessions. To challenge large banks beyond the stress observed in the past, we create an artificially severe stress-test scenario using the available Bank of Canada modelling tools. The following sections summarize the modelling of a plausible stress exercise and why it is important to link the stress scenario with the current macrofinancial conditions in the context of CBDC.

2.2. CBDC impact on banks may depend on macro and market conditions

The impact of CBDC on the financial system should be considered in the context of the corresponding macro/market conditions and the central bank's policy, which we refer to as a scenario.

Different stress scenarios may interact with a CBDC to different degrees, depending on which vulnerabilities are triggered and how the financial system responds to them.

- **Low versus high interest rate scenarios**

Stress scenarios are often characterized by elevated inflation and thus typically involve some periods of high policy interest rates. In such environments, banks face higher funding costs, making it more expensive to replace deposits withdrawn into CBDC holdings. Nevertheless, **the environment with high interest rates may overall be better suited for large Canadian banks to respond to CBDC** because, on average, it corresponds to an environment with higher net interest income margins for banks. This happens due to

⁸ Previous recessions in Canada are COVID-19 recession from the first to the third quarter of 2020, the global financial crisis from the fourth quarter of 2008 to the second quarter of 2009, the dot-com bubble recession in the first and second quarters of 2001, the recession from the second quarter of 1990 to the first quarter of 1992, two joint recessions in 1980–82 and a recession from the fourth quarter of 1973 to the second quarter of 1975, all determined as times with two consecutive quarters of GDP decline.

⁹ Early adopters are typically individuals who are less risk-averse and receive higher benefits from the new technology, often taking advantage of being the “first movers” (Rogers 1995; Catalini and Tucker 2016). However, the s-curves also take place because the innovator/firm continues to improve the product after receiving feedback from the early adopters, which makes it more popular among the late adopters (Rogers 1995).

asymmetrical pass-through of the policy rate (see **Chart 1**).¹⁰ When the policy rate increases, the increase propagates more to lending rates rather than to borrowing costs, allowing banks to retain higher net income margins.¹¹ At present, the Canadian policy rate remains sufficiently elevated and supports strong bank profitability, which provides a partial buffer against potential negative impacts from CBDC (see section 2.12 for further discussion).

- **Domestic versus foreign stress**

CBDC may have different impacts on banks' vulnerabilities depending on which financial stress is triggered. For instance, a **Canada-specific stress may have a larger impact** on Canada-centric banks and be more interactive with CBDC, given that the domestic banks are subject to more deposit outflows.

- **Quantitative easing versus tightening cycles**

The macrofinancial environment associated with quantitative easing (QE) or tightening (QT) also conditions the effects of CBDC. The central bank may have more flexibility responding to CBDC if it holds large settlement balances. In the most likely CBDC design, withdrawals from banks to CBDC will first require the banks to acquire sufficient settlement balances. An insufficient amount of settlement balances in the economy may result in banks selling government bonds to obtain settlement balances, which would result in the central bank increasing its balance sheet. In this case, second-round impacts of larger settlement balances should be also considered (e.g., pricing and liquidity shortages in fixed-income markets).

2.3. Demand for CBDC is conditional on stress scenarios and bank behaviours

While our exercise is focused primarily on banks, it is important to understand how the demand for CBDC from households may be impacted by stress, since CBDC demand and bank deposits are endogenously determined. The **appeal of CBDC to bank depositors may vary across the business cycle** and broader macroeconomic conditions. For example, during periods of low policy rates, retail deposit rates tend to decline, making a non-interest-bearing CBDC relatively more attractive (see **Chart 1**). This dynamic was particularly evident between 2020 and 2022, when the average deposit rate paid by Canadian DSIBs fell below the average deposit fee. As a result, retail deposits became unprofitable for households that did not benefit from bundled services such as payment functionality, access to credit, fraud protection or investment advice (see **Chart 1**). However, the relationship between the business cycle and demand for CBDC is not straightforward.

¹⁰ Competition among banks and with other financial institutions is crucial in determining the level of pass-through from the policy rate to the deposit rate (Drechsler, Savov and Schnabl 2017). Compared with that of other countries, Canada's banking system is highly concentrated, which results in Canadian DSIBs charging higher rents. In addition, Canadian banks hold mortgages that are subject to more frequent repricing than, for instance, those in the United States.

¹¹ This effect, however, holds only on average and in the short term depends on the specifics of the recession and financial market sentiment. Recently, there also appeared a tendency of banks to propagate policy rates more to the depositors, as documented for the United States (Kang-Landsberg, Mordel and Beaudry 2023). One explanation for that is increased fintech competition.

Chart 1: Historical bank rates and profitability dynamics

Chart 1A: deposit rates.

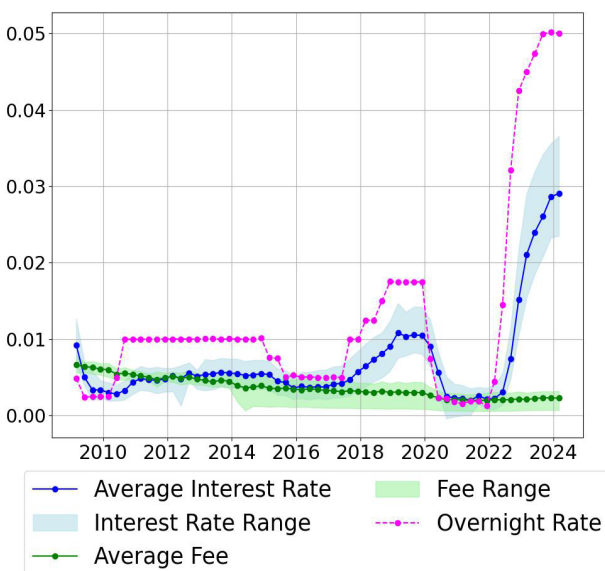
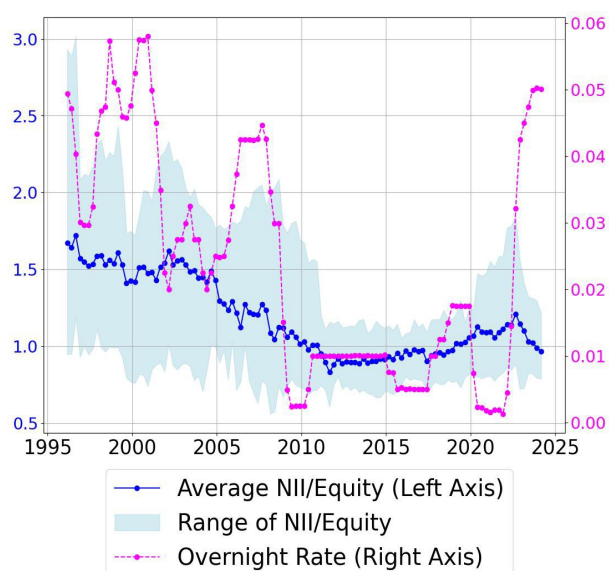


Chart 1B: bank interest margins.



Note. Chart 1A: Average interest rate and fee on demand deposits of DSIBs compared with the Bank of Canada overnight rate. An increase in the Bank overnight rate is transmitted to higher interest paid on demand deposits by the domestic systemically important banks, with transmission being weaker for high rates. The average deposit fee is showing low sensitivity to changes in the policy rate.

Chart 1B: An increase in the Bank of Canada overnight rate leads to a higher net interest income (NII) margin for DSIBs over the medium term (NII is measured as a ratio of net interest income and equity). While the transmission is not perfect, the trend indicates a generally positive impact of elevated policy rates on banks' profitability through enhanced interest income.

Sources: Authors' calculations based on M4/P3 regulatory banking reports for DSIBs; BoC rates data.

Low policy rates also encourage household borrowing, which strengthens relationships between households and banks, discouraging migration to CBDC.¹² Beyond the business cycle effect, severe financial stress may also constrain households' liquidity, impacting their demand for deposits. This indicates that, in theory, demand for deposits and CBDC may be scenario dependent.

Modelling CBDC demand and realistic bank behaviour endogenously poses considerable challenges, especially when bank-level predictions are required. Instead of relying on highly complex general equilibrium models, this paper employs a structural model approach. This approach relies on the fact that apart from the cases of panics and bank runs, individual deposits remain sticky over time, including during recessions. A common explanation for the stickiness of deposits is that **banks strategically keep their deposits steady under various macroeconomic conditions**. This means

¹² Bernanke and Gertler (1995) was among the first to offer an explanation of this effect based on net worth of households. Namely, collateral required for obtaining credit becomes more valuable during low-interest rates times.

that if deposits become less attractive to households during certain episodes, banks adjust rates or fees just enough to retain the changes in the depositor base within reasonable limits.

In the stress exercise, we assume that banks value stability of deposit growth. If deposits change too much, banks are penalized by friction costs with sensitivity parameters, which we estimate empirically (see Appendix 1 for details). If banks need to expand or contract their deposits, they can make deposits more/less attractive to households by changing rates and fees on deposits. The banks may also change their deposit base for the sake of profitability or regulatory compliance.¹³ Therefore, strategic responses of banks result in endogenous deposits—and thus also **endogenous CBDC demand within our exercise**.

The endogeneity setup makes it difficult to calibrate the total amount of CBDC in circulation consistently with other studies on CBDC in Canada, which assumed small changes in banks' balance sheets. To tackle this problem, we follow a **two-stage approach to CBDC demand calibration**. First, we benchmark (non-equilibrium) CBDC demand with a non-strategic balance sheet assumption using the previous (survey-based) estimates of CBDC demand for Canada. Second, we run the exercise with banks' strategic responses to CBDC and stress. This results in updated CBDC demand. In the strategic run, we find to which degree banks choose to retain depositors by offering them better deals on deposits; in certain cases, banks choose to reduce their deposit base even more for financial stability reasons.

We condition benchmarked CBDC value to three different designs and distribution models of the Canadian digital dollar, consistently with the previous policy notes. The **key distinction between the first two designs lies in the intended use of CBDC: whether it is used primarily for point-of-sale (POS) transactions or for broader use—as both a general method of payment (MOP) and a store of value (SOV)**. To further amplify stress and account for unforeseen circumstances, we also consider a third design involving banks facing additional deposit outflows. These outflows may occur, for instance, when banks encounter increased competition from fintech firms.

In all designs, CBDC is assumed to be non-interest bearing and free for households to hold. For simplicity, we also assume that, in each of the three cases, other financial institutions (non-DSIBs) proportionally experience outflows to CBDC.

Banks and fintech firms can also benefit from the innovative features of CBDC by becoming contractors or distributors of such services, which we do not consider. Similarly, banks can gain from advances in the fintech industry. Thus, the proliferation of fintech should not necessarily take on a negative form as assumed in the MOP/SOV CBDC + Fintech case. To remain conservative in our

¹³ In support of this, [Drechsler, Savov and Schnabl \(2017\)](#) find that cyclic changes in US deposits are driven by shifts in the deposit supply curve rather than the demand curve determined by households. Similar intuition applies to Canada.

CBDC designs and benchmark outflows in the exercise

1. POS CBDC Financial institutions (FIs): Can \$7 billion CBDC outflows DSIBs: Can \$5.7 billion CBDC outflows -0.3% of retail bank deposits	POS CBDC is used primarily as a method of payment for point-of-sale transactions. It contains the best features of cash and debit methods of payments. ¹
2. MOP/SOV CBDC FIs: Can \$171 billion CBDC outflows DSIBs: Can \$136 billion CBDC outflow -7% of retail bank deposits	MOP/SOV CBDC is used as store of value and method of payment for point-of-sale, peer-to-peer (P2P), and online transactions. The distribution network of CBDC includes digital wallets/accounts, bank branches and post offices, allowing for in-person customer service and support. ^{1, 1}
3. MOP/SOV CBDC + Fintech FIs: Can \$171 billion CBDC outflows & Can \$128 billion Fintech outflows DSIBs: Can \$245 billion total outflows -8.5% of retail bank deposits -5% of corporate deposits	MOP/SOV CBDC + Fintech is similar to MOP/SOV CBDC but is also subject to additional ad hoc deposit outflows to Fintech firms.

predictions, we do not consider the positive changes stemming from these fintech innovations in this work, and the impact of fintech is limited to the deposit market share.

2.4. Channels through which CBDC exacerbates bank vulnerabilities

The impact of CBDC on banks is more severe during times of stress than in normal periods because of the need to replace deposits with more expensive and less stable funding combined with lower initial regulatory ratios.

CBDC forces banks to replace funding with costly alternatives. Financial stress critically impacts funding costs, making **CBDC's effect on profits more severe during stressful periods**. Additionally, banks face credit and securities losses, leading to much lower ex post profit levels compared with normal times.

The impact of CBDC on profits leads to a **dynamic negative impact on capital**: reduced profits in the short term lead to less capital in the long term, which also **slows the growth** of bank balance sheets. However, this does not necessarily lead to a marginally higher impact of CBDC on capital ratios, because when banks reach low capital ratios in stress, they become more sensitive to any marginal changes applied to them. As such, **CBDC may have a lower marginal impact on capital ratios during stress than during normal times**.

The expectation channel also plays an essential role in capital depletion, as banks begin capital provision ahead of time to account for the future credit losses.¹⁴ As a result, CBDC may have a bigger impact on banks if their high adoption resonates with the time when provision for credit losses (PCL) ratios are adjusted.

Liquidity of banks is likely to be impacted more by CBDC during stress than during normal times. This happens because banks become funded by **more flighty liquidity**, which exposes them to runs. However, this effect may be mitigated if the banks precautionarily choose or will be required to hold more liquid assets with CBDC.

2.5. Bank of Canada stress-testing tools used for CBDC analysis

Banks' balance sheet management in times of stress is a complex, dynamic process involving many variables and behavioural responses. Among central bankers, it is a common practice to use a macro-financial scenario as a skeleton for the remaining projections. In particular, stress is often modelled using time-series regression analysis and structural behavioural models, which are tied to the macro conditions (e.g., unemployment, inflation, growth dynamics) and interest rate policies. This will also be the approach that we adopt.

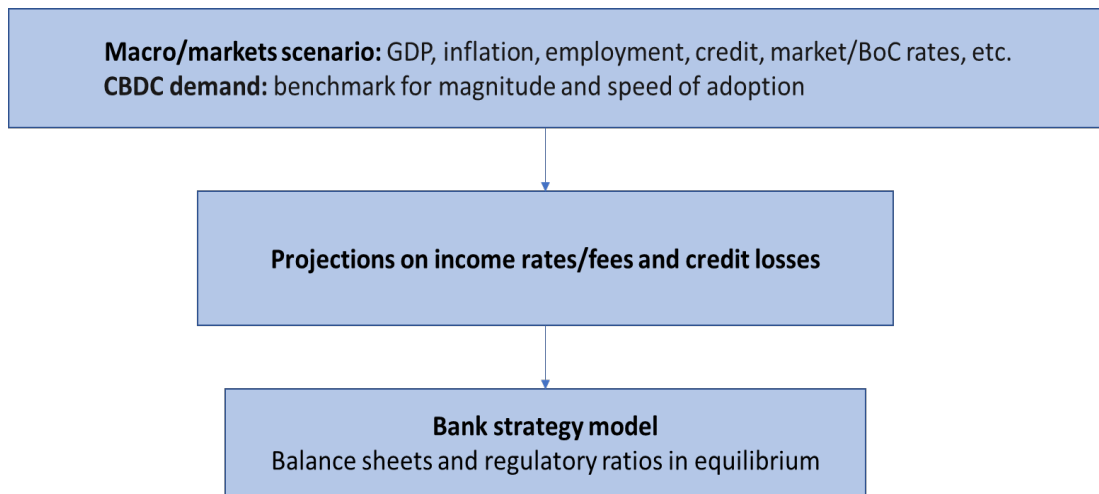
We simulate stressful conditions for the Canadian banks using the Bank of Canada Framework for Risk Identification and Assessment (FRIDA).¹⁵ The framework is applied in stages (see **Figure 1**).¹⁶

¹⁴ In 2018, [IFRS 9 banking regulation](#) came into effect requiring banks to provision for expected rather than actual credit losses. See [Office of the Superintendent of Financial Institutions \(2022\)](#) for more details.

¹⁵ An alternative approach to CBDC analysis was to use the historical stress data during various macro conditions, such as historical funding spreads, and apply similar stress to the case with CBDC (see [Auer et al. \(2024\)](#) for an exercise on Italian banks). We find this approach to be less useful because there are only a few historical stress episodes in Canada and significant changes in banks' business models and regulation over the past decade. A more advanced but still limited approach in the literature was to utilize loan demand elasticities to interest rates and separately apply behavioural assumptions about banks' lending (see [Carapella et al. \(2024\)](#) for an exercise on US banks). This approach also results in the lack of consistency of adjustments in various assets and liabilities, detachment from the current macro conditions, and unclear impact of small changes in regulatory ratios on the behaviours of banks.

¹⁶ We extend FRIDA's credit default model ([Bruneau, Duprey and Hipp 2022](#)) to more loan types and apply it using bank-level data. The interest rate model is not originally part of FRIDA ([Hałaj and Traclet 2022](#)) and was created only for the purpose of the exercise.

Figure 1: Enhanced Bank of Canada Framework for Risk Identification and Assessment (FRIDA) with CBDC Demand Assumptions



1. We specify a **macro-consistent scenario by a hypothetical narrative and numerical projections** for national GDP, unemployment, bond yields, corporate spreads, foreign exchange and similar variables for closely related countries. Having a narrative that focuses only on a few macroeconomic variables helps one to understand the uniqueness of the scenario, compare it with historical episodes and previous stress tests, and avoid regression errors that arise when too many endogenous variables are modelled simultaneously.
2. We proceed with the credit default model—a time-series (quantile) regression model that produces **probabilities of default for various bank loans**, depending on the scenario and the quantile that is chosen (e.g., the 50% quantile historically corresponds to the expected loan default rates, but lower quantiles are typically selected in stress-testing to account for unlikely and severe default rates that follow “fat tail distribution”).
3. Using a macrofinancial scenario and credit losses as the inputs, we apply the interest rate model—an autoregressive time-series regression model that projects **interest rates and fees charged or paid by banks** on loans, retail and term deposits, corporate funding, securities and other exposures.
4. Our principal analysis is conducted using the bank strategy model—a structural banking model, which aligns the historical **balance sheet changes of banks** with the incentives to maintain stable regulatory ratios, high profits and limited risk.¹⁷ The inputs of the model are projected trends for loan default rates and income rates (calculated as average return rates

¹⁷ See [Halaj and Priazhkina \(2021\)](#) for the original version of the banking model and applications. The model has been since enhanced by incorporating reputational/regulatory and transition costs in the utility functions in [Hipp and Ojea-Ferreiro \(forthcoming\)](#).

per balance sheet category), as well as the distribution of Monte Carlo shocks that can generate paths beyond the projected average paths.¹⁸ As additional inputs, we also calibrate banks' business models using historical data (e.g., dividend payout ratios, recovery potential and maturity of loan portfolio, hedging strategies, regulatory requirements, credit loss provisioning, etc.).

2.6. Assumptions about bank behaviours for CBDC analysis

We model the responses of banks to CBDC and stress from the point of view of a portfolio manager by allowing banks to rebalance large categories of assets and liabilities each quarter. These top-level decisions can be supported by bank branches in different ways; for example, branches can increase their deposit base by offering promotions and new bundles of services to depositors. We do not specify in detail how exactly the banks attract or retain customers, or which borrowers will be the first to let go. However, we account for the changes in the banks' customer base and repricing of their services by using empirically estimated elasticities on the funding and asset income margins. These elasticities quantify how changes in each balance sheet item will affect expected profitability coming from the changes in market shares of other banks (see **Appendix 1**).

When deciding on the new balance sheet composition, the **banks are driven by the expected return on equity, while also minimizing reputational and regulatory costs**. In particular, banks are penalized for a low liquidity coverage ratio (LCR), weighted capital ratio (CET1) and leverage ratio through estimated sensitivity parameters (see **Appendix 1**).

Banks' dividend payout ratio is chosen to meet the average level observed during the global financial crisis; no additional equity is raised. This limits the flexibility of banks and makes the impact more severe.

2.7. Description of an extremely severe scenario

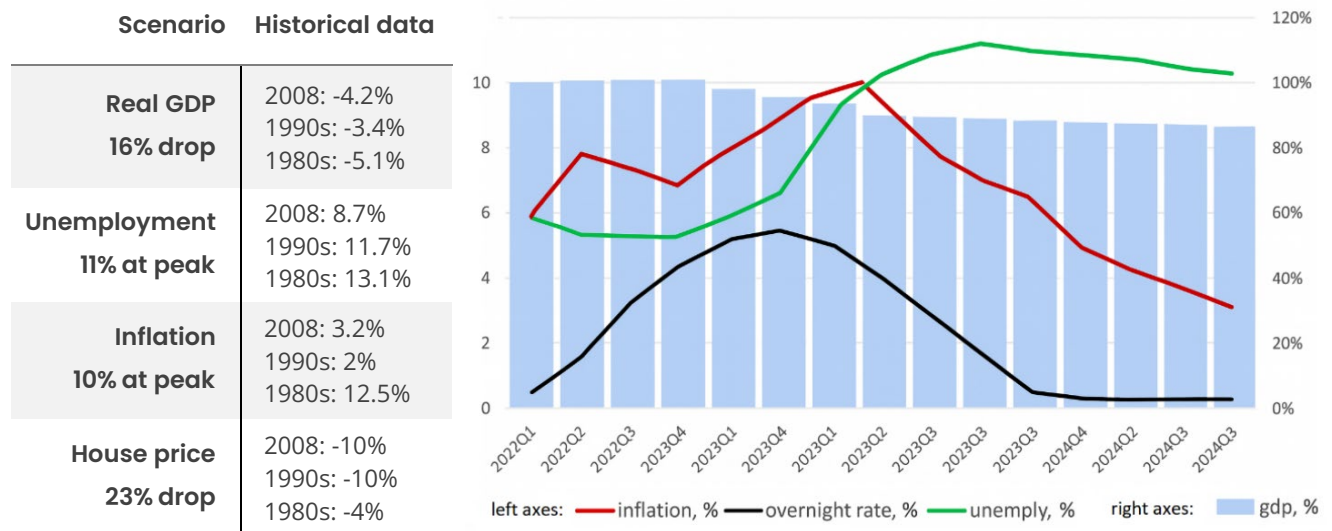
In the following sections, we report the results for the scenario that serves an aggravated version of the Global Stress Test scenario supplied by the Basel Committee on Banking Supervision, the Financial Stability Board and the International Monetary Fund to the Bank of Canada for the years 2023–25. The stress described in the scenario is extremely severe and unlikely to occur; it also cannot be interpreted as a forecast for the near future. However, even in this scenario, CBDC has a negligible impact on the regulatory ratios of banks and leads to a mild reduction in bank lending. We recommend **interpreting these results as the worst-case outcome** for banks under severe stress

¹⁸ The shocks are bootstrapped from historical banking data, conditional on the specified regressions for both income and loan default models. The shocks are then applied in the banking model in the Monte Carlo fashion. This allows us to generate "black swan" events in the financial markets, reach more severe stress, and account for natural volatility of banks' returns, which cannot be explained by the high level macrofinancial variables. Such fluctuations also impact the behavioural choices of banks regarding their assets and liabilities.

Chart 2: Macro-financial conditions during the simulated stress test scenario

Chart 2A: scenario highlights.

Chart 2B: dynamics of key scenario variables.



Sources: simulated projections after 2023Q1; historical data prior to 2022Q4.

with CBDC. The analysis includes a range of CBDC assumptions, varying the scale and speed of adoption as well as the associated policy responses intended to mitigate potential impacts.

The scenario narrative includes persistent inflation, continued disruptions to global supply chains, and additional commodity price shocks, leading to sharp increases in energy prices as well as tensions in the equity and bond markets. This situation is further exacerbated by a drop in house prices, depreciation of the Canadian dollar, and negative expectations. In addition, the scenarios are characterized by large liquidity shocks and higher corporate spreads.

In our scenario, inflation increases to 10% at its peak, real GDP drops by 16%, unemployment rises to 11% at peak, and average house price decreases by 23%. This makes this **scenario more severe than recent historical stress episodes** in Canada (see **Chart 2**). In the scenario, the Bank of Canada responds first by increasing the policy rate to fight inflation, and then by lowering the policy rate to mitigate the financial stress.

We apply several **CBDC demand and policy assumptions** that intensify the scenario:

- The adoption of CBDC begins in early 2023 and lasts for only three years, with **adoption dynamics resembling the S-curves typical of new technologies**. This leads to a 15% exogenous (benchmark) adoption rate by the end of the first year, 85% by the end of the second year and 100% by the end of the third year. The endogenous responses of banks will slightly change the distribution of withdrawals over time, but the S-curve pattern will persist (see **Appendix 2**). In section 4.1, we also present results from an additional exercise in which

the CBDC adoption is accelerated to last only two quarters.

- Financial institutions are unsettled by **high CBDC demand and a competitive fintech sector** (MOP/SOV CBDC + Fintech), which results in the exogenous benchmark of Can\$299 billion outflows from the financial system and Can\$245 billion from DSIBs directly. In section 2.10, 2.11 and 3.1, we extend the results to the assumptions regarding POS and MOP/SOV CBDC demand.
- Banks comply with **stricter LCR regulations** following the introduction of CBDC, since deposit outflows become less stable. By definition, LCR is the ratio of weighted liquid assets to weighted liabilities that are subject to withdrawal within one month. In the formula, each type of liability is assigned a runoff rate that reflects the type of depositor, the purpose of the deposit and the residual maturity. We assume that the Office of the Superintendent of Financial Institutions (OSFI) requires banks to hold additional high-quality liquid assets immediately at the start of the scenario, which is achieved by imposing a higher runoff rate on deposits. The runoff rate for retail deposits changes by 0.05 units, indicating that 5% more retail deposits are likely to be withdrawn within a month during a period of stress. For comparison, the current regulatory runoff rate on retail deposits is 0.03–0.05 units for “stable” deposits and 0.10–0.40 units for “less stable” deposits. For corporate demand deposits, the change in runoff rate is assumed to be 0.08 units, indicating that 8% more corporate demand deposits are likely to be withdrawn within a month. In section 4.4, we challenge these assumptions by varying the runoff rates.

We assume normal **central bank operations** adjusted to CBDC issuance, such that:

- CBDC is treated as an asset by the central bank, and thus it can be obtained by the payment providers only as a result of exchange for another asset, for example, settlement balances or high-quality collateral. For simplicity, we assume that for the conversion of other forms of money to CBDC, such as deposits, the payment providers are required to have an equivalent buffer of settlement balances available to them solely for operational purposes. DSIBs are also assumed to serve as payment providers.

Severe stress leads to a **temporary suspension of quantitative tightening**, with the central bank holding Can \$302 billion in government bonds starting from June 2023 until the end of the scenario (small variations in settlement balances are ignored). We assume that settlement balances beyond Can \$50 billion can be used by FIs, which results in the estimated buffer of Can \$114 billion to process withdrawals of depositors into CBDC.¹⁹

¹⁹ This is consistent with the intention of the Bank of Canada to continue quantitative tightening until the central bank's balance sheet size reaches Can \$20 billion to Can \$60 billion (or 1%–2% of Canadian GDP) and to condition quantitative tightening on the stress episodes (see [Gravelle 2024](#)). The optimal amount of settlement balances reserved for the floor system operations is estimated at Can \$50 billion as a rule of thumb and in reality will depend on a variety of factors, including the regulatory environment, participants' liquidity preferences and the gross quantity of government debt outstanding ([Bulusu et al. 2023](#)).

- To process Can \$171 billion of withdrawals to CBDC, FIs first use Can \$114 billion of pre-existing settlement balances and then obtain the remaining Can \$57 billion of CBDC by exchanging government debt for settlement balances through **open-market operations** (see section 3.2 for details).
- When additional settlement balances are created by the Bank of Canada for CBDC, DSIBs sell government bonds in proportions **consistent with the historical average**. Part of the bonds are sold on behalf of smaller banks and non-bank financial institutions (see section 3.2 for details).

2.8. Results: Banks replace one-third of deposit outflows with other funding

We begin analyzing the results of the stress test exercise by examining the impact of banks' behavioural responses. Over the course of three very stressful years, DSIBs on average lose Can \$177 billion in retail deposits due to CBDC and fintech, compared with the non-CBDC scenario (see **Chart 3A**). This is equivalent to -7.6% retail deposits with respect to the final balance sheets. Thus, the equilibrium outflows exceed Can \$163 billion (-6.9%) of retail outflows imposed exogenously (see **Chart 3B**). This occurs because, under stress, **banks prioritize preserving regulatory ratios and profitability over maintaining deposit volumes**, leading them to reduce lending more aggressively than the initial CBDC-related outflows alone would require.

Banks also choose to respond to the increased fintech competition. They retain Can \$8 billion of corporate demand deposits by offering firms higher returns, and eventually letting Can \$73 billion of corporate deposits go to the competing fintech.

Despite banks reducing deposits, banks are still subject to higher rates on deposits. CBDC and fintech drive up competition for deposits, which results on average in a 15 basis points increase in the annual retail deposit rate and an 8 basis points increase in annual corporate demand deposit rates.

To replace funding lost to CBDC, DSIBs increase their corporate term deposit base by Can \$27 billion (+1.2%) and their repo funding by Can \$56 billion (+4.7%). The short-term funding is preferred by DSIBs because it is less expensive and easier to source. In summary, only **one-third of lost deposits is replaced by the alternative funding**.

Despite negative impacts, deposits of DSIBs increase over the period of three years. Thus, **the stress only slows the positive growth of deposits without pushing it into negative territory**, decreasing the average annual growth rate from 6.7% without CBDC to 4% with CBDC. Updates in the LCR formula force banks to further rebalance their funding toward long-term corporate and (collateralized) repo funding. This policy measure has a small impact on the retail deposits (resulting in Can \$9 billion of outflows).

Chart 3: Marginal impact of CBDC on funding structure and retail deposits

Chart 3A: funding rebalancing.

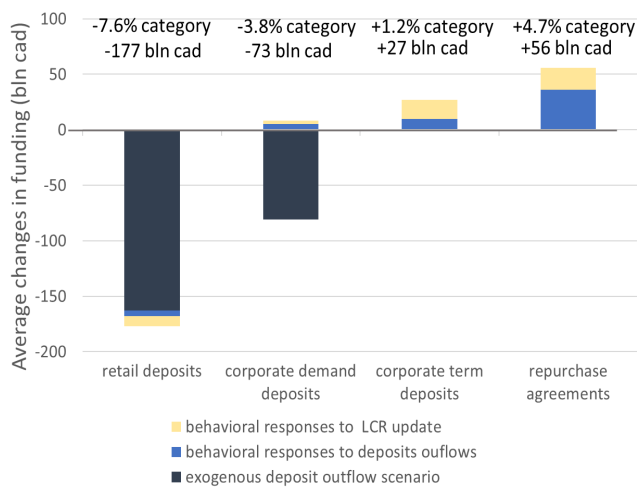
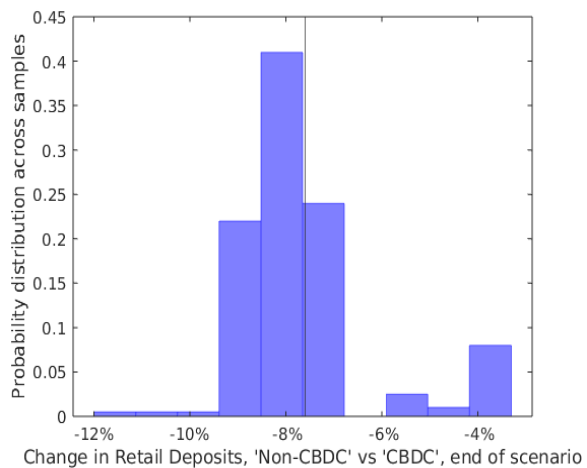


Chart 3B: retail deposits changes.



Note. Chart 3A: impact of CBDC on the largest funding categories presented as the sum of three negative/positive components: exogenous demand scenario, behavioural responses, and LCR update. The values are average differences across samples between CBDC and non-CBDC scenarios. It is assumed that Can \$163 billion of retail and Can \$81 billion of corporate demand deposits migrate from the balance sheets of DSIBs if they do not respond to the outflows (black color). For obtaining other results, the model is sequentially executed twice. First, only deposit-outflows assumptions are applied (blue color shows model output beyond exogenous outflows). Second, both deposit outflows and LCR regulatory weights assumptions are applied (yellow color shows marginal changes in the model output comparing to the first run). The final net outflows are Can \$177 billion for retail deposits, Can \$73 billion for corporate demand deposits, and inflows are Can \$27 billion for corporate term deposits, and Can \$56 billion for repurchase agreements. MOP/SOV CBDC + Fintech case is assumed.

Chart 3B: histogram of projected retail deposit outflows from DSIBs due to CBDC in comparison to non-CBDC, sampled outcomes depend on the realization of the credit and income Monte Carlo shocks. MOP/SOV CBDC + Fintech case is assumed.

2.9. Results: CBDC has very low impact on capital ratios in stress

Banks continue to meet regulatory requirements even during extremely severe stress, with all DSIBs remaining above the set requirements of 9.5% for the risk-weighted capital ratio, 3.5% for the leverage ratio and 100% for the liquidity coverage ratio (see section 4 for the discussion on regulatory limits). In particular, final capital ratios fall from an average of 12.6% to 11.7%; leverage ratios fall from an average of 4.8% to 4.7%; and liquidity ratios rise from an average of 136% to 152% (see **Table 1**). In the last quarter, the lowest average values across DSIBs are 9.8% for capital, 3.8% for leverage, and 134% for liquidity. In the worst quarter of the scenario, ratios decrease to an average value of 9.6% for capital, 3.9% for leverage and 117% for liquidity across DSIBs. This

Table 1: Impact of stress scenario and CBDC on DSIB’s regulatory ratios in comparison to the regulatory limit and starting point ratios.

		Historical, before stress, average DSIB	Stress, last quarter, average DSIB	Stress, last quarter, lowest DSIB	Stress, worst quarter, average DSIB	Limit
LCR	Base Stress	1.36	1.52	1.34	1.17	> 1
	CBDC Stress		1.25	1.15	1.10	
CAR	Base Stress	12.6	11.7	9.8	9.6	> 9.5% 10.5% before stress 11.5% now
	CBDC Stress		11.7	9.7	9.6	
LEV	Base Stress	4.8	4.7	3.8	3.9	> 3.5%
	CBDC Stress		4.7	3.7	3.9	

Note. The regulatory ratios are reported as average values across all simulations. LCR – Liquidity Coverage Ratio, CAR – Weighted Capital to Asset Ratio, LEV – leverage ratio. Columns labelled “last quarter” contain 2025Q4 average ratios, column labelled “worst quarter” contains results for the minimum of regulatory ratio within the stress scenario. MOP/SOV CBDC + Fintech case is assumed.

Sources: simulated model results for 2023Q1 - 2025Q4, modelling assumptions, OSFI website.

indicates that the **scenario is impacting the DSIBs significantly as it places them at their regulatory limits** at the pick of the stress.

Alongside this significant stress, CBDC barely reduces the average capital and leverage ratios (less than 0.1 percentage points for each of the two ratios, as shown in **Table 1**). This happens because **banks become defensive of their regulatory ratios, when they operate close to the limits, and find other ways to mitigate CBDC impact** (see sections 2.11 on income and 3.1 on lending impacts). The impact on capital and leverage is more severe for banks with the most affected ratios; however, the impact on ratios still remain minimum.

Due to LCR runoff rates being updated as a response to CBDC, the LCR ratios drop suddenly with stress and reach, on average, 125% at the end of the stress scenario with CBDC. In comparison, DSIBs finish with 152% LCR without CBDC. This indicates that **banks have no problem adjusting to the new LCR weights even during the severe recession** (see section 4.4. for the discussion on LCR policy update) **in situations where a policy update is not announced in advance**.

2.10. Results: With high CBDC demand, banks face more outflows

To this point, we have reported the results for the scenario where DSIBs are affected by significant outflows to CBDC and fintech (MOP/SOV CBDC + Fintech). We will now apply comparable macrofinancial conditions to the two other cases of benchmark outflows, POS and MOP/SOV (see section 2.3).

POS: when CBDC is used mainly for making payments in stores rather than for storing funds, banks experience a retail deposit loss of 0.8% (Can \$19 billion) in comparison with the exogenous benchmark of 0.3% (Can \$7 billion). The majority of these deposit changes come from the update in the LCR requirement. Without the LCR policy update, the decrease in retail deposits would be at 0.2% (Can \$5.8 billion), the changes in corporate term and repo funding would grow by Can\$1 billion altogether, while the corporate demand funding would be reduced by roughly Can\$0.5 billion. This indicates that **banks would retain a larger fraction of deposits-at-risk when the exposure to CBDC is low, with stricter liquidity regulation prompting most reduction in deposit growth.**

MOP/SOV: When CBDC is frequently used as both a store of value and a method of payment but fintech is not outcompeting banks, retail deposits decrease by 4.1% (Can \$96 billion) in comparison with the exogenous benchmark of 5.8% (Can \$136 billion). Banks choose to retain one-third of deposits-at-risk by increasing deposit rates by 7 basis points on average. Without the LCR policy update, the decrease in retail deposits would be very similar, precisely at 4.2% (Can \$99 billion). These results indicate that **if banks are negatively impacted by the additional outflows to fintech, they are less likely to retain retail deposits** moving to CBDC (Can \$40 billion are retained in the case without fintech versus an additional Can \$14 billion are reduced with fintech).

2.11. Results: CBDC impacts profits and profitability

CBDC negatively impacts banks' profits. However, due to strategic responses to CBDC, banks manage to stay profitable even during the very severe scenario, with average impacts being higher when higher deposit outflows take place:

POS:	7% cut in profits
MOP/SOV:	11% cut in profits
MOP/SOV + Fintech:	15% cut in profits.

Despite a reasonable reduction in profits in dollar terms, banks on average maintain **nearly the same profitability** (return on equity [ROE]) as without CBDC:

POS:	0.3 percentage points cut in ROE
------	----------------------------------

MOP/SOV: 0.4 percentage points cut in ROE

MOP/SOV + Fintech: 0.6 percentage points cut in ROE

For comparison, over the last decade, average ROE of Canadian DSIBs stayed at 13.9 percentage points, few percentage points above their peers in other countries. Therefore, the DSIBs would still compare favourably with peers in other countries after the introduction of CBDC.

The **impact of CBDC on profits and profitability is likely to be small but subject to some uncertainty**. The profit impact can range from -30% to +10%, depending on the realization of income and credit losses. The ROE impact can range from -6 pp to +4pp, compared with the average of 13.9 percentage points a decade earlier. Such a wide range of outcomes appears due to extreme and unexpected shocks assumed in the scenario and is unlikely to take place in the real future (see **Chart 8**).

To highlight the importance of dynamic strategic responses, it is useful to align our income predictions with the previous CBDC exercises for Canada. The [Bank for International Settlements \(2021\)](#) analysis considered two extreme (non-behavioural) responses of Canadian banks to CBDC. In both cases banks were assumed to lose 20% of their assets to CBDC, which were replaced with long-term wholesale funding. In the case when banks did not pass on higher funding costs to borrowers, the authors predicted ROE would decrease by 0.9 percentage points, on average. Alternatively, when banks wanted to maintain their pre-CBDC ROE, they would need to increase lending rates by approximately 50 basis points. Performing a similar exercise, [Garcia et al. \(2020\)](#) found that Canadian DSIBs' ROE would decrease by almost 1 percentage point, assuming 11% of their balance sheet migrated to CBDC. The authors took a more conservative view on the funding stability impact by assuming banks would need to turn to less stable sources. Our **current results indicate that CBDC will have a smaller impact on profitability than previously predicted** in these two studies, even in the most severe stress. There are several explanations for that. First, we proceed with smaller CBDC demand. Second, in the behavioural model, **banks mitigate the impact of CBDC** on profits by retaining most profitable asset and liability exposures when reducing their balance sheet. This means that banks replace some CBDC outflows with cheaper short-term funding and likely spend less funds on the competition and client search for the remaining assets. Third, during stress, banks naturally reduce their deposit growth as part of their cyclical balance sheet adjustments. As a result, reduction needed for CBDC outflows is partially accounted for by the balance sheet adjustments caused by the stress itself.

2.12. Discussion: DSIBs are likely to stay strong in other stress scenarios

We have shown that DSIBs stay resilient to stress and CBDC. The basis for that is the presence of policy scrutiny, high market power and timing advantage. Despite using a particular stress scenario

to make our predictions, we are confident that this resilience is likely to remain in other stress scenarios.

- a) The **current capital positions of Canadian DSIBs are strong a priori**, especially following Basel III reforms. From the average capital ratio of only 9.1% in the first quarter of 2015, banks grew their capital to 12.6% by the fourth quarter of 2022. In comparison, the new capital limit for DSIBs during that time was 10.5%. This indicates that large banks have become significantly more capitalized, even according to the current capital standards. Furthermore, advanced Basel formulas for risk-weighted capital were created to ensure that banks remain resilient in various scenarios, even when the performance of the banking portfolio is unusually low. Since the end of 2023, the OSFI capital requirements have increased from 10.5% to 11.5% to protect the banks against rising risks. This placed DSIBs slightly below the limit and urged them to accumulate capital. However, this regulatory increase is likely to be reversed during times of stress. Once banks accumulate a sufficient amount of capital and the recession hits, regulators will reduce the capital requirement to ease pressure on banks and allow them to maintain lending to the real economy. This dynamic in capital regulation exists because one component of the regulatory capital buffer (called the Domestic Stability Buffer, or DSB) is countercyclical and contingent on the financial environment. In the stress scenario reported in sections 2.8 and 2.9, we assumed a DSB reduction of 1% due to the severity of the stress situation. However, **regulators can reduce capital requirements by an additional 2%, down to 8%**, which is the core capital limit for systemically important banks (see section 4.3 for further exercises). This flexible approach to capital regulation also indicates that in the most severe scenarios, regulators may lower the capital limit, ensuring banks remain compliant even when CBDC losses are incurred.
- b) The substantial market power of DSIBs not only boosts their profit margins but also leads to smaller funding elasticities, further enhancing their stability in the face of new financial technologies and CBDC. It means that **banks can replace deposits with alternative funding sources without incurring large transaction costs**. Part of this stability comes from DSIBs having access to the international funding markets.
- c) COVID-era quantitative easing (QE) measures in the United States and Canada significantly increased settlement balances and **elevated liquidity coverage ratios of DSIBs**. These strong liquidity positions helped limit the impact of CBDC on LCRs in our analysis. Even under severe stress, LCRs are expected to remain above regulatory thresholds. While the scenario assumes an abrupt drop in LCRs due to sudden changes in regulatory formulas, in reality, banks are likely to face a gradual transition. This would allow them to adjust over time and rebuild liquidity buffers more effectively.
- d) In the scenario, we made CBDC adoption a short-term but gradual process by assuming a three-year horizon. This allowed for additional credit provisions to be applied before the funding cost losses occurred. With quicker CBDC onboarding, banks may face higher funding costs sooner. In section 4.1, we run alternative simulations assuming CBDC is adopted within an abnormally short period, only two

quarters. However, it is more likely that the adoption of **CBDC will be a longer-term process**, lasting five years or more (see section 2.2 for historical evidence).

- e) The timeline of our analysis begins in a **high-interest-rate environment**, which results in DSIBs earning elevated profit margins and comfortably absorbing the stress. This happens because in Canada the large banks retain high market power, which allows them to pass through the policy rate hikes to deposit rates only to a small degree, while charging higher rates for loans. When CBDC decisions are made, the policy rates may decrease, which will reduce the profitability of DSIBs. If in the future the rates decrease to pre-COVID levels and major financial vulnerabilities materialize, the stress analysis may need to be run again to re-evaluate the effect of CBDC.

In conclusion, the banks will likely remain strong in alternative scenarios. The primary reason for this is the numerous assumptions that we adopted in the severe stress scenario. Among them are high CBDC demand, quick CBDC implementation, strong fintech sector growth, severe funding market stress, and abnormal performance of loans on the banks' portfolio. In reality, these **negative outcomes are unlikely to materialize altogether**.

3. Second-round effects of CBDC related to banks

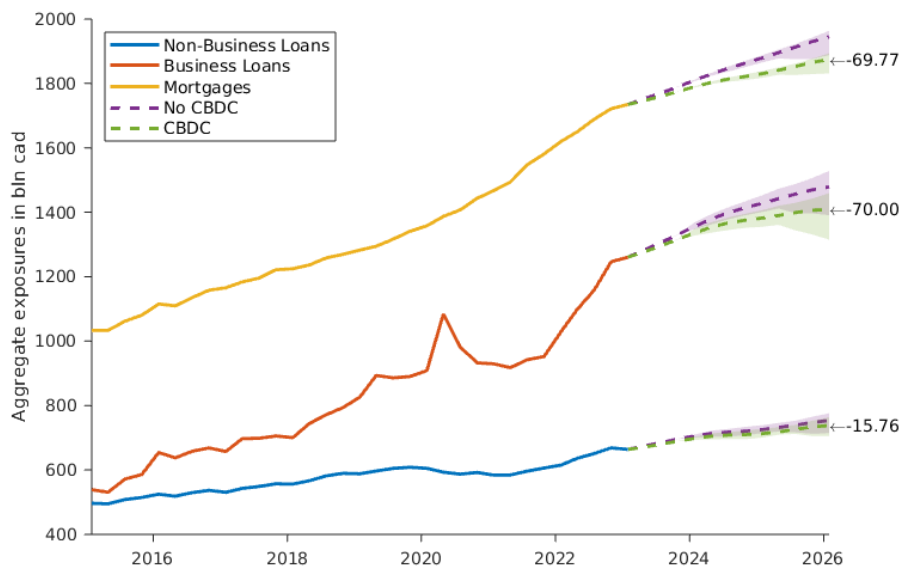
3.1 Results: CBDC negatively impacts lending to real economy

Impacted by outflows of deposits to CBDC, banks are forced to either seek more expensive funding or reduce their assets, approximately half of which are loans to the real economy.²⁰ Reduction in assets also helps to preserve capital ratios, which are impacted by rising funding costs. This reduction is unavoidable in times of severe stress, when banks' capital ratios drop to or below regulatory limits (see section 2.9). We find that in the most severe scenario (MOP/POS + Fintech), DSIBs cut lending to businesses and households by an average of 5.5% when compared with the stress scenario without CBDC. The highest reduction takes place in non-business loans (-7.6%), followed by business loans (-4.6%) and mortgages (-3.5%). However, the effect of CBDC is too small to do more than slow the growth of DSIB lending. **The average loan growth during stress slows down from 5.4% without CBDC to 3.4% with CBDC**. In comparison, loan growth in the year preceding the stress was at 12% (see **Chart 4**).

When outflows to CBDC are lower, banks decrease lending to an even lesser degree. In the POS CBDC case, lending exposure decreases by 1.7%, resulting in a lending growth of 4.7% by the end of the scenario. In the MOP/SOV CBDC case, the reduction in lending exposure is 4.5%, while the lending growth rate is 3.8%. One may wonder whether a more general result can be derived for the

²⁰ This mechanism is consistent with the traditional bank lending channel literature emphasizing the importance of deposit funding for bank intermediation (see [Stein 1998](#), [Kashyap and Stein 2000](#)).

Chart 4. Dynamics of DSIB loan portfolios before stress and under simulated stress in two scenarios



Note. The purple region shows simulated outcomes without CBDC, while the green region represents outcomes under the MOP/SOV CBDC + Fintech scenario. Dashed purple and green lines denote expected outcomes, aggregated across DSIBs and averaged across Monte Carlo simulations. Numerical values next to arrows indicate the marginal impact of CBDC on reductions in non-business loans, business loans, and mortgages in the final quarter of the scenario (aggregated across DSIBs and expressed in billions of CAD).

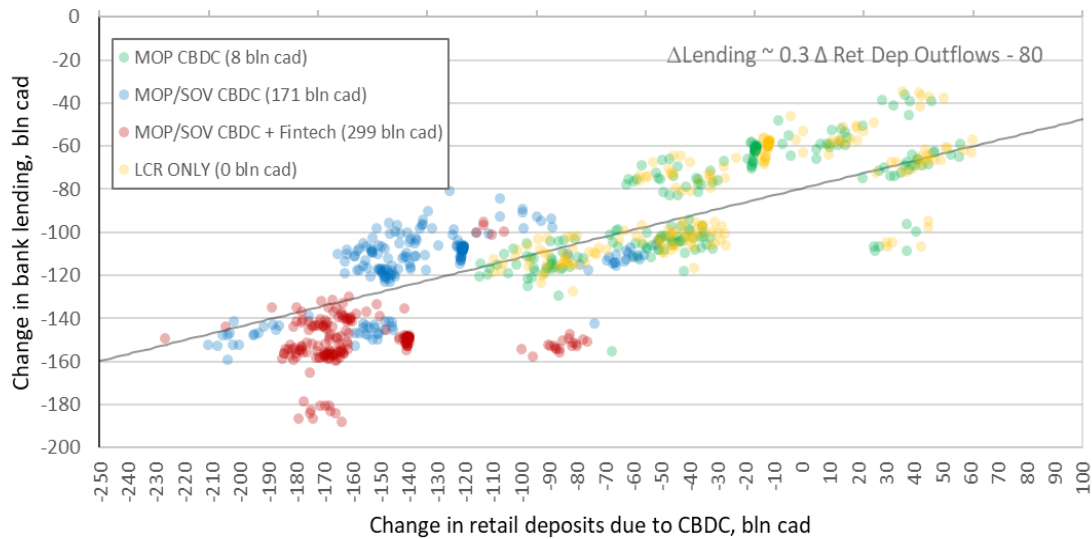
Sources: historical observations prior to 2022Q4, simulated results for 2023Q1 - 2025Q4

average DSIB pass-through relationship between deposits and lending growth with CBDC. Historically, the pass-through for the banks has been very stable over time. Similar stability in the pass-through is observed in our results: **each \$1 increase in the deposit outflows leads to 0.3 times reduction in lending** (see **Chart 5**).²¹ This pass-through rate stays roughly unchanged for small changes in CBDC demand, but it will change if CBDC is adopted too quickly (see section 4.1)

Another notable observation is that when CBDC demand is relatively small (POS CBDC), banks may increase deposits depending on the macrofinancial conditions (**Chart 5**). This result requires more explanation in the context of CBDC literature. [Andolfatto \(2021\)](#) confirms that interest-bearing CBDC may increase deposit volumes and promote higher deposit rates by serving as an interest rate floor. [Chiu et al. \(2023\)](#) also find that CBDC could increase lending by improving deposit competition. Competition would force banks to increase deposit rates, which would in turn attract more deposits,

²¹ Similar pass-through rate between deposits and lending have been predicted for the U.S. banking system. Using another structural banking model, [Whited et al \(2022\)](#) find that \$1 deposit market share captured by a non-interest-bearing CBDC would reduce chequing deposits by \$0.7, savings deposits by \$0.1, but lending only by \$0.2. In addition, the authors run another simulation based on bank size and find that the pass-through in lending doubles for smaller banks due to their higher wholesale funding costs. The authors also find CBDC's impact to be smaller when the banking system is more concentrated, as then banks have larger buffers to absorb CBDC's impact.

Chart 5. Pass-through between deposit and lending reduction



Sources: simulated results for 2025Q4.

resulting in more funds available for lending.²² Differently, our results take place even when no interest is paid on CBDC. In fact, the positive impact of CBDC on lending in our exercise has a different nature than the papers mentioned above, namely, the LCR regulation update. Because deposits become treated as more unstable in the LCR formula, banks rebalance toward more stable sources of funding and liquid assets. This policy update may have an ambiguous impact on the banks, depending on the scenario. Without an LCR policy update, we find that CBDC always leads to a decrease in deposits, consistently with [Sanches \(2022\)](#), [Whited et al. \(2022\)](#), and [Keister and Sanches \(2023\)](#).

3.2 Impact of CBDC on banks depends on the central bank operations

The Bank of Canada is responsible for the effective implementation of monetary policy. It achieves this objective by injecting or withdrawing intraday liquidity and maintaining the target overnight rate through repurchase agreements. It also conducts monetary policy actions related to quantitative easing and tightening, which impact the amount of settlement balances in the economy. Because banks participate in the markets for government debt, depending on the state of the central bank operations, CBDC may have a different impact on banks and other financial institutions.²³

²² In the model of [Chiu et al. \(2023\)](#) this result holds for concentrated markets, assuming CBDC pays interest and banks do not have access to non-deposit funding. [Chiu and Davoodalhosseini \(2023\)](#) show that an interest-bearing CBDC can increase bank intermediation even when the banking sector is competitive. An interest-bearing CBDC increases demand for goods from consumers receiving interest payments on their CBDC and deposit balances. This, in turn, increases the demand for loans to finance the production of goods.

²³ See [Barrdear and Kumhof \(2016\)](#) for more intuition.

Banks that are required to process withdrawals of deposits to CBDC would be required to first obtain high-quality collateral, most likely settlement balances. If banks use existing settlement balances to repay withdrawing depositors, this has no impact on the size of the central bank's balance sheet. However, **if banks must liquidate some assets to process the withdrawals, CBDC onboarding may expand the central bank's balance sheet.**

An increase in the central bank's balance sheet may lead to further second-round effects on banks. When settlement balances are high, the impact of CBDC on banks will be more mitigated, reducing the need for banks to sell assets. Reversely, when there are not enough settlement balances, the central bank may choose several ways to "back up" the CBDC issuance on the asset side. The most likely choices include purchases of government bonds and overnight repo operations. In our exercises, we assumed the former approach, as open market operations have historically been the preferred tool for implementing long-term, planned interventions similar in nature to CBDC (see **Chart 6**). At the same time, **CBDC does not require a special policy for the settlement balances** management and can be considered together with other regular management of central bank's reserves. Thus, the ratios of government bond purchases, repo operations and other collateralized lending for CBDC purposes can vary across time, if the volatility of CBDC purchases and withdrawals is considered.²⁴

Theoretical literature on CBDC also considers other ways of backing CBDC, among which are direct uncollateralized loans to private banks (e.g., [Brunnermeier and Niepelt 2019](#)). While central bank lending is unlikely to take place without collateral, this conceptual exercise is useful to explain how **the central bank's response to CBDC can dampen the negative impact of CBDC** on banks.

Imagine if the central bank provides funding to banks on the same conditions as were given deposits prior to CBDC. Then central bank loans directed to private banks could be used to replace deposits migrated to CBDC, and in this way maintain stable banks' funding and lending to real economy. So the central bank could, in theory, completely mitigate the impact of CBDC on banks and the economy.

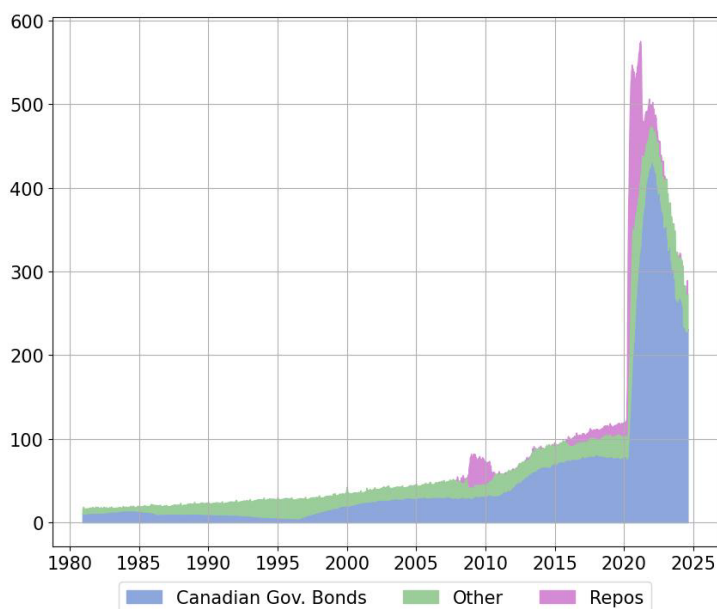
There are two reasons why in reality this theoretical setup is unlikely. First, central banks prefer lending to illiquid but only solvent banks requiring sufficient collateral for a loan ([Bagehot 1873](#)).

²⁴ Using repo purchases to "back up" CBDC may have an advantage to bond purchases in the situation where the Bank of Canada has already purchased too much of the bonds. In particular, repo purchase does not lock the bond on the balance sheet of the central bank, which helps to maintain sufficient market depth and liquidity by letting the necessary bonds circulate in the market. Government bonds, on the other hand, would stay on the central bank's balance sheet for long time and possibly have an impact on central bank profitability and ability to conduct monetary policy if needed in the future.

On the other hand, repo operations may create more balance sheet issues for dealers, as dealers cannot net them that easily. Thus, backing up CBDC with repo would further enlarge the balance sheets of the dealer banks. This effect, however, can be mitigated by an accompanying leverage ratio relief (see section 4.5).

It is also important to consider further differences between lending (repo) and open market operations (government bond purchases) when issuing CBDC, such as operational easiness of conducting the transactions for the Bank.

Chart 6: Assets on the Bank of Canada balance sheet.



Source: Bank of Canada website.

Thus, providing uncollateralized stable funding to banks is not aligned with the typical duties of the central bank. The second reason of why CBDC is not neutral is the two-tiered system of primary dealers and non-bank financial institutions (NBFIs) (Bolduc-Zuluaga et al. 2022). When open market operations take place, a fraction of government bonds transaction with the central bank is on behalf of other financial institutions such as wealth managers (open-ended mutual funds, exchange-traded funds and alternative funds) and pension funds. This happens because NBFIs do not have access to the central bank bond auctions and thus cannot participate in the open market operations directly (DSIBs earn profits from providing intermediation services to them). This makes the impact of CBDC more complex. If the existing auction setup will be in place for the open market operations, the **two-tier system of banks and NBFIs** will create the following impacts:

- The central bank's balance sheet will increase by more than what is required for banks to replace CBDC due to banks performing some transactions with the central bank on behalf of other financial institutions.²⁵
- Balance sheet sizes of DSIBs and their LCR will increase marginally because of NBFIs temporarily parking their liquidity at the banks.

²⁵ Papers that explore asset-side policies of CBDC include Juks (2018), Kumhof and Noone (2021), and Adalid et al. (2022). These papers highlight that CBDC issuance coupled with government bond purchases in the open market will have a variable impact on bank funding depending on whether asset purchases are directly purchased from banks or from the non-bank sector. Recent theoretical work by Niepelt (2024) extends this reasoning by providing a tractable framework in which reserves, CBDC, and bank deposits coexist and interact with central bank asset choices, reserve remuneration, and CBDC policy design. His findings underscore that CBDC issuance—even when non-remunerated—can alter equilibrium deposit and reserve holdings depending on whether CBDC is substitutable for deposits or reserves.

3.3 The impact on market liquidity is likely to be mitigated using standard measures

In the scenarios where CBDC is actively used as both a method of payment and a store of value, the Bank of Canada may be required to create additional settlement balances, which will live for a short period only, while deposits are transferred to CBDC. Such a transition may happen quickly and to a larger degree than during normal times. Therefore, additional measures may be applied for how settlement balances are created. First, non-special bonds may be selected to avoid market liquidity problems when implementing monetary policy. At the same time, it is recommended that the diverse composition of the purchased bonds be maintained (e.g., in terms of maturity) when issuing CBDC to limit the ownership of certain types of bonds and in this way not crowd out other investors. Corporate and provincial bonds can also be considered, although special attention should be paid to the risk that these bonds bring to the Bank of Canada's balance sheet. In stress, the bond purchases can also be accompanied by lending from the Bank of Canada to the financial sector through repos or advances and to the private sector (i.e., through corporate bonds) to ease the financial conditions of banks. Given the estimated outflows to CBDC, we expect the **impact on the bond market** to be small. Three reasons support this statement. First, bonds will be purchased by the private sector over a long period of time, likely during quantitative tightening. Second, the total central bank balance sheet will be smaller than during the COVID episode. Finally, the central bank is also likely to hold a more balanced portfolio of bonds by the time CBDC is introduced. All these reasons give confidence that if temporary settlement balances will need to be created for CBDC, **the market impact will be mild, compared with past episodes.**

Literature on CBDC also points out that **liquidity in the money markets** can be another source of instability during CBDC take off, due to banks using short-term funding to replace lost deposits. We find that less than a third of retail deposits will be replaced with short-term funding; thus, the impact on the repo and wholesale funding markets is expected to be limited and extended through multiple years. However, **additional monitoring of the money markets can be performed** during the deployment of the CBDC, especially given the role that DSIBs play as the market dealers. If the transition to CBDC takes place quickly during stressful events, the high demands for short-term

Table 2. Comparison between gradual (3 years) and accelerated (2 quarters) CBDC introduction. The regulatory ratios and reductions in exposures are reported as average values across all simulations for 2025Q4: MOP/SOV CBDC + Fintech vs no CBDC cases.

	Gradual CBDC	Accelerated CBDC
LCR	1.25	1.25
CAR	11.7	11.5
LEV	4.7	4.5
Retail Deposits	Can \$177 billion (7.6%) outflows 3.4% annual growth	Can \$192 billion (8.1%) outflows 2.8% annual growth
Loans	Can \$149 billion (3.5%) reduction	Can \$215 billion (5.1%) reduction

Sources: simulated model results

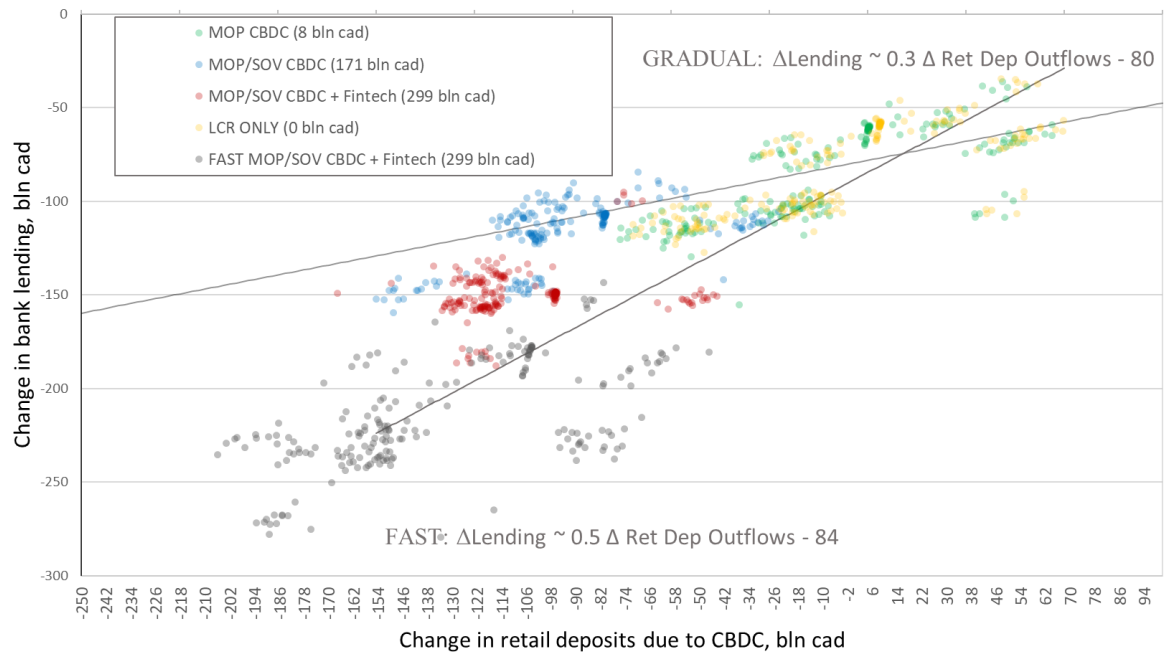
funding may be exacerbated by the simultaneous increase in liquidity needs from asset managers (Fontaine et al. 2021). In this case, additional central bank liquidity facilities can be used to alleviate dealers' balance-sheet constraints (Cimon and Walton 2024).

4. Policy responses to mitigate negative impacts of CBDC during stress

4.1. Gradual implementation of CBDC adoption helps banks and the real economy

If CBDC is adopted too quickly by depositors, DSIBs may not have sufficient time to replace outflows with lower-cost funding. DSIBs also require time to adjust their long-term loan contracts and securities positions. In our model, we incorporate two frictions that limit rapid adjustment:

Chart 7: Disintermediation of DSIBs depending on the CBDC demand assumption, random income and credit shocks, and the speed of CBDC deployment.



Note. Slopes of the lines visually represent the average pass-through rate between funding outflows and lending for accelerated and gradual CBDC deployment.

empirically estimated marginal costs associated with balance sheet changes, and restrictions allowing changes in lending only through maturing contracts. These mechanisms slow banks' response to CBDC shocks.

To assess the importance of adoption speed, we rerun the stress scenario from section 2.7 assuming that CBDC is adopted over six months (75% in the first quarter and 25% in the second quarter), rather than gradually over three years.

We find that **faster adoption leads to sharper declines in capital and leverage ratios, along with greater deposit outflows** (see **Table 2**). The most significant impact is observed on lending: under fast adoption, loans are reduced by Can \$215 billion (5.1%) over the stress period, compared with Can \$149 billion (3.5%) with gradual adoption. The standard pass-through of 0.3 times between deposit outflows and lending no longer holds. Instead, each Can \$x billion in deposit outflows leads to a Can \$0.5x billion reduction in lending (see **Chart 7**), indicating **increased disintermediation under accelerated CBDC deployment**.

Acceleration in CBDC deployment also leads to **greater uncertainty around DSIB profitability**. Although the average reduction in final-year net income and ROE is lower with fast adoption (-5%

Chart 8: Comparison between the income effect of gradual (3 years) and accelerated (2 quarters) CBDC.

Chart 8A: net income distribution.

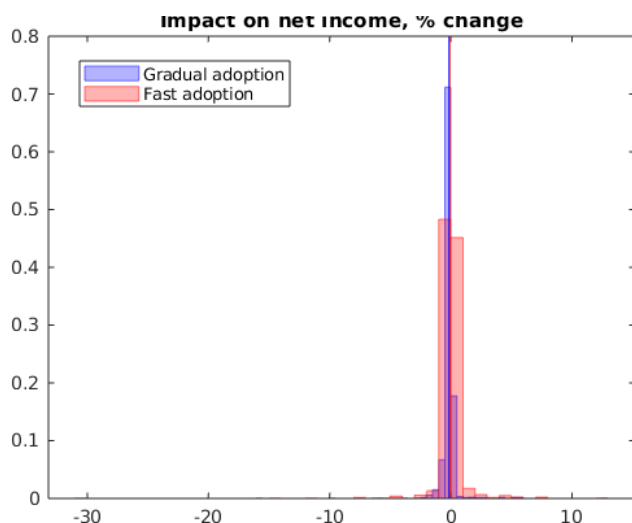
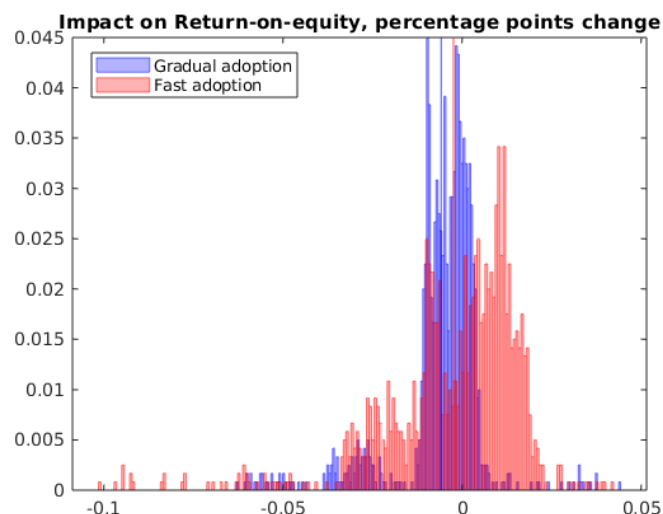


Chart 8B: return-on-equity distribution.



Note. Blue and red graphs are histograms of net income and profitability (ROE) effects of CBDC. The comparison is made between the final quarter of the stress scenario with CBDC and without CBDC.

Sources: simulated model results.

and -0.2 percentage points) than with gradual adoption (-15% and -0.6 percentage points), outcome variability is higher. Accelerated rollout increases the likelihood of extreme negative profit scenarios (see **Chart 8**).

These findings highlight the importance of a gradual CBDC implementation timeline. A phased approach allows banks to better manage funding transitions, preserve lending to the real economy, maintain regulatory ratios, and avoid severe income shocks under stress conditions.

4.2. CBDC limits

Personal limits on CBDC holdings could be a useful policy tool for supporting financial stability, even if applied temporarily.

If CBDC issuance involves central bank operations with government debt or high-quality assets, there is a **natural limit on the amount of CBDC a central bank can issue**. This assumes the central bank is independent from the fiscal authority and committed to holding a limited amount of high-quality assets (Williamson 2022b). The central bank's independence from the fiscal authority means it cannot issue new government debt for operational purposes. Thus, the CBDC amount is limited by the quantity of free-floating debt and high-quality collateral for CBDC issuance.

Nonetheless, in current policy discussions, this natural limit is often considered non-binding. In fact,

regulators are thinking of **limiting CBDC in circulation even more, for instance, by using personal CBDC limits.**

Limits on CBDC holdings and transactions may be useful for multiple reasons:

- a) Limits may effectively reduce the deposits at risk of migration, assisting banks in preserving established lending relationships.
- b) Binding limits may also **reduce pressure on banks** in the long run and thus position CBDC more favourably to them; this could encourage banks to act as the payment service providers in the two-tier distribution model of CBDC and support the system operationally.
- c) Limits may **reduce the volatility of central bank operations** during stressful times, when depositors quickly exchange their deposit funds into CBDC.
- d) Limits may **decrease incentives for depositors to run to CBDC** during bank panics.
- e) Limits could help ensure that the **adoption of CBDC remains gradual and controlled**, allowing central banks to monitor its impact on the economy and adjust policies as necessary. This phased approach helps avoiding sudden shocks to the financial system and ensures that CBDC complements other programs (such as open banking, quantitative tightening and payments system upgrades).

However, overly strict or permanent **limits may undermine CBDC's potential benefits**. If adoption falls short of critical thresholds, consumers may rely more heavily on costlier payment methods like credit cards, leading to higher transaction costs passed through by dominant networks (e.g., Visa, Mastercard). High limits are also important for attracting early adopters, whose participation is necessary for building network effects and merchant acceptance.

Different countries approach CBDC limits differently. The analysis and policy work conducted for the European Union and the United Kingdom are good examples of the regulatory thought process on limits.

- In the **United Kingdom**, Bank of England and HM Treasury proposed limit between **£10,000 and £20,000** on holdings of digital pound **during a transition period**, which would allow 75% to 95% of UK citizens to receive their pay in digital pounds. The limit would constrain bank outflows and allow UK authorities to learn more about the CBDC's impact in the early stages and “strike an appropriate balance between managing risks and supporting wide usability of the digital pound” ([Bank of England and HM Treasury 2023](#)).
- **European Union** regulators and researchers have paid significant attention to the CBDC limits. Among others, [Burlon et al. \(2024\)](#) provide a general equilibrium analysis of CBDC limits. They find that a non-remunerated, unlimited CBDC would absorb around 13% of liquid assets. To preserve bank credit and maximize welfare, they recommend limiting CBDC to 6% of liquid assets through a combination of holding caps and negative interest (e.g., holding fees). Under

this approach, average CBDC balances align with European Central Bank former board member Fabio Panetta's suggested limit of EUR 3,000 per person.²⁶

These examples raise important questions about whether CBDC limits in Canada need to be temporary or permanent and how quickly the limits can be released to protect lending to the real economy. In our exercise, we first modify the demand for CBDC as if a permanent holding limit is imposed. We then compare it with the case when the same limit is imposed temporarily and **released after the first two years**. Because imposing limits makes sense only when the demand for CBDC is high enough, we focus on the case when CBDC is frequently used as both a method of payment and a store of value, also assuming increased fintech competition. We also focus on a two-year limit because the adoption does not gain enough momentum for the limit to be released earlier. For simplicity, we assume that the temporary limit only delays adoption but does not discourage people from holding CBDC eventually when the limit will be released. In other words, when testing the temporary limits, we essentially vary the S-curve by shifting from early to late adoption, while holding the total benchmark deposit outflows fixed.

As shown in **Table 3**, temporary CBDC limits help safeguard bank lending to the real economy. By preserving profits in the early stages of the scenario, these limits allow banks to reinvest sooner and expand their balance sheets more quickly than in cases where early profit losses occur.

This demonstrates the usefulness of temporary limits and encourages a variety of future experiments on the limit amount and the timing of the release, and other CBDC design features. The stress-testing analysis on limits should also be complemented by the bank run simulations, which can reveal whether limits are successful in slowing down the deposit outflows during sudden panics.²⁷

²⁶ The limit has been tested in several studies, starting from [Bindseil \(2020\)](#) and [Bindseil and Panetta \(2020\)](#). [Adalid et al. \(2022\)](#) also impose a limit of 3,000 digital euros per individual assuming all citizens use cap fully and 50% of the substitution is from bank notes. The results show that 8% of household and non-financial corporate deposits could be displaced. [Meller and Soons \(2025\)](#) confirm that with the limit, changes to banks' funding structures and their liquidity risks would have been moderate. The authors test this limit using historical data with high reserves and low reserves. They conclude that the limit would make it unlikely for banks to become illiquid during bank runs into digital euros. [Assenmacher et al. \(2023\)](#) go one step further by allowing for the incremental introduction of CBDC and also considering foreign effects. The authors predict that the transition to CBDC may cause demand for CBDC to overshoot in the short run, thereby crowding out bank deposits and lending. They propose EUR 3,000 holding limits on CBDC in the European Union to help smooth the transition to the new equilibrium.

²⁷ See [Fernández-Villaverde et al. \(2021\)](#), [Keister and Monnet \(2022\)](#), [Williamson \(2022a\)](#), [Ahnert et al. \(2023\)](#) and [Bidder, Jackson and Rottner \(2024\)](#) on the impact of CBDC in bank run panics.

Table 3. Impact of CBDC limits on bank lending. The regulatory ratios and in exposures are reported as average values across all simulations for 2025Q4: MOP/SOV CBDC + Fintech vs no CBDC case.

<i>Scenario</i>	<i>Total retail deposit outflows</i>	<i>Reduction in lending</i>
<i>No limit</i>	12%	Can \$155 billion (5.5%)
<i>Can \$50,000 temporary limit within two years</i>	12% (delayed transition)	Can \$145 billion (3.5%)
<i>Can \$25,000 temporary limit within two years</i>	12% (delayed transition)	Can \$132 billion (3.1%)
<i>Can \$10,000 temporary limit within two years</i>	12% (delayed transition)	Can \$124 billion (2.9%)
<i>Can \$50,000 permanent limit</i>	10%	Can \$148 billion (3.5%)
<i>Can \$25,000 permanent limit</i>	8%	Can \$147 billion (3.5%)
<i>Can \$10,000 permanent limit</i>	5%	Can \$137 billion (3.3%)

Sources: simulated model results and demand estimations with benchmarks based on Li et al (2023).

4.3. Bank capital regulation

A decline in banks' profits caused by CBDC adoption can hinder capital accumulation, creating a **trade-off between maintaining regulatory capital ratios and supporting credit** to households and businesses. This trade-off becomes more pronounced during periods of financial stress, amplifying the adverse impact on credit compared to a scenario without a CBDC.

In Canada, the Domestic Stability Buffer (DSB) serves as a macroprudential tool to help preserve bank lending during downturns. The DSB is a countercyclical capital buffer maintained during periods of economic strength and released during stress to absorb losses and support credit provision. The buffer can range from 0% to 4% and is currently set at 3.5%, as part of the 11.5% CET1 requirement for Canada's six DSIBs.

Chart 9: Impact of Domestic Stability Capital Buffer (DSB) on DSIBs' final capital ratios and lending reduction.

Chart 9A: loan reduction.

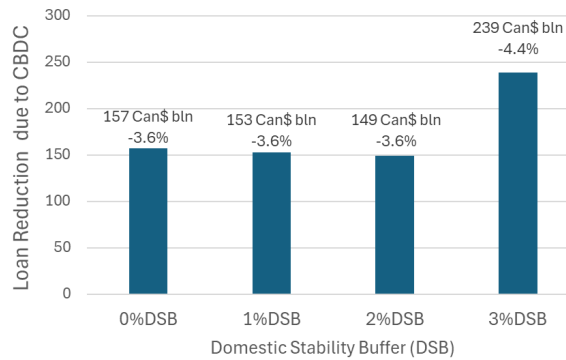
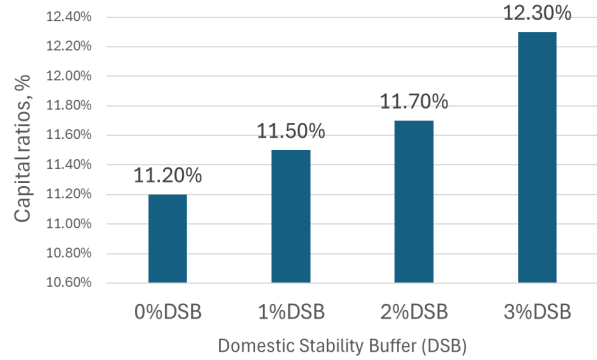


Chart 9B: capital ratios.



Note. Chart 9A: reduction in total loans in bln (vertical axe) and in % relative to the no CBDC scenario. Chart 9B: average capital ratio. Results are reported for the final quarter of the scenario; the average across simulations and DSIBs is taken.

Sources: simulated model results.

The DSB could be leveraged to mitigate the effects of CBDC by

- 1) establishing more efficient coordination between regulatory agencies, including the Bank of Canada, for the **buffer to be released more quickly** in case of financial stress during CBDC deployment
- 2) **timing a period of DSB accumulations before the deployment of CBDC** to release capital pressure from banks during the adoption.²⁸

Chart 9 shows the trade-off between varying the DSB from 0% to 4% for lending protection and higher capital requirements in the stress test exercise. Reduction in the DSB from 3% to 2% leads to a much stronger protection of lending than from 2% to 1% or from 1% to 0%. Moreover, changes in the capital buffer between 2% and 0% have minimum impact on lending. This reminds one about the **limited advantage of capital reliefs**. In the first two quarters of the scenario, the stress is still not severe enough (see **Chart 2**), and during this time, a higher capital limit encourages banks to build the capacity, which will be utilized to absorb shocks later in the scenario. If the capital requirement is reduced too much and prematurely, banks enter severe stress in weaker positions.

²⁸ Capital release may require careful implementation to support the real economy. See [Schroth \(2021\)](#) for the discussion on the stability buffer trade-off.

4.4. Bank liquidity regulation

The introduction of a central bank digital currency may exacerbate funding instability of banks, particularly in the short term. Banks are already accustomed to managing liquidity risk arising from the maturity mismatch between assets and liabilities: deposits are typically short-term, while loans and securities are longer-term and less liquid. In times of significant outflows, these assets may not be easily convertible to cash. To address this risk, banks must adhere to the LCR and NSFR. The LCR requires banks to hold enough high-quality liquid assets (HQLA) to withstand a 30-day liquidity shock. The NSFR ensures that long-term assets are funded by stable liabilities over a one-year horizon. Both ratios depend on assumptions about the liquidity of a bank's assets and the stability of its liabilities.

In Canada, OSFI provides detailed calibration of these ratios through the Liquidity Adequacy Requirements (LAR) Guideline.²⁹ For LCR calibration, deposits are assigned runoff rates based on characteristics such as depositor type, account purpose and the strength of the depositor's relationship with the bank. Deposits from individuals or small businesses that are considered stable—such as primary transaction accounts with regular inflows—typically receive runoff rates in the 3%–5% range. Less stable deposits, including those without strong customer relationships or more rate-sensitive in nature, can carry runoff rates between 10% and 40%.

CBDC adoption may affect these classifications. For example, **some retail deposits may become more susceptible to withdrawal into CBDC, which could warrant higher runoff rates, new deposit buckets or revised assumptions about liquidity.** CBDC may also lead banks to increase reliance on certain instruments, such as repurchase agreements, potentially requiring their revaluation as HQLA. Finally, CBDC could trigger revisions to bank reporting standards, requiring more detailed data, and updates to intraday monitoring systems.

The regulatory LCR changes caused by CBDC are also likely to be complemented (or even accounted for) by other liquidity regulatory updates that OSFI undertakes to respond to increased digitalization, payment system modernization, and a changing interest rate environment.³⁰

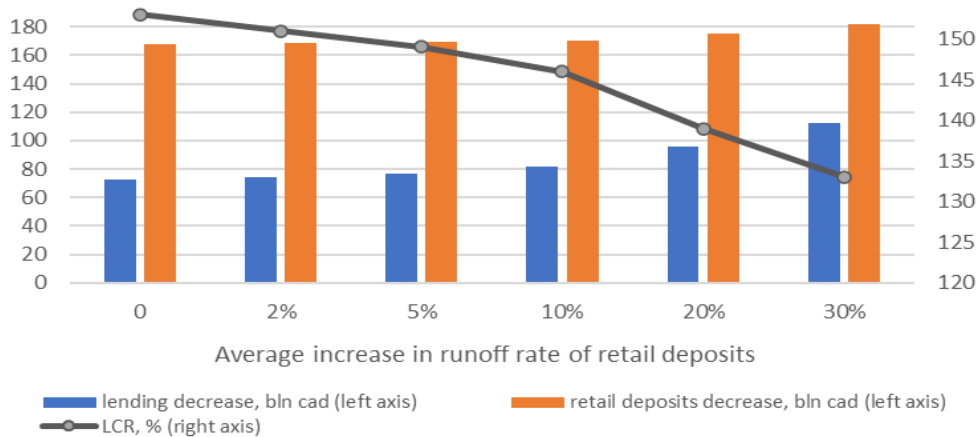
If LCR calibration is revised, this would directly affect the central bank in two key ways. First, it would provide the Bank of Canada with more time to respond to funding instability under CBDC. Second, changes to liquidity rules may impact bank lending and overall financial stability, which fall within the Bank's mandate.

To evaluate the mid-term impact of such LCR update, we run a series of exercises with gradually increasing the average runoff rate of retail deposits. When the LCR regulation is tightened, banks must hold a larger proportion of their assets in HQLA, such as government bonds or reserves at the central bank, which are considered highly liquid and low-risk. Thus, LCR requirement can reduce the

²⁹ LAR Guideline should be read in conjunction with the [Basel Committee on Banking Supervision's \(BCBS\) Principles for Sound Liquidity Risk Management](#) and [Supervision and OSFI's Guideline B-6: Liquidity Principles](#).

³⁰ See [OSFI's Annual Risk Outlook for 2024–25](#) (Office of the Superintendent of Financial Institutions (2024)).

Chart 10: Impact of increase in the LCR runoff rates on DSIBs' liquidity coverage ratio, lending reduction and retail deposit reduction



Note. Results are reported for the final quarter of the scenario; the average across simulations and DSIBs is taken.

Sources: simulated model results.

amount of banks' funds available for other purposes, including lending. The banks may also prefer to reduce their exposure to (less stable) retail deposits altogether for easier compliance with LCR.

In **Chart 10**, we demonstrate that when the runoff rate of retail deposits increases by 0.02-0.05, retail deposits decrease by an average of Can \$1 billion to Can \$1.5 billion by the end of the stress. Such a change is accompanied by a reduction in lending of Can \$1.3 billion to \$4.3 billion, meaning **banks prefer restructuring their asset portfolio rather than reducing lending in response to CBDC and LCR updates**. When the runoff rate of retail deposits increases by 0.10-0.20, retail deposits decrease by an average of Can \$2 billion to Can \$7 billion by the end of the stress, also causing a drop in lending by an average of Can \$9.3 billion to Can \$23.3 billion. For comparison, the current regulatory runoff rate on retail deposits ranges from 0.03 to 0.05 for the stable part of deposits and between 0.10 and 0.40 for less stable deposits. This indicates that when retail deposits migrate from the stable to the unstable category, it may have a significant impact on lending. Because maintaining lending is essential during stress, it is **recommended to proceed with changes in LCR regulation ahead of stressful events**. Moreover, other measures can be implemented for stability of retail deposits, such as:

- establishing CBDC limits and time-sensitive monitoring
- strengthening customer relationships between banks and depositors
- enhancing trust in the Canadian banking system through increasing awareness about deposit insurance and banking supervision
- providing clear and transparent information about the bank's financial health at the current time

- ensuring robust security for digital banking platforms and awareness about it to reduce customer fears about digital theft
- adjusting deposit insurance coverage

4.5. Bank leverage regulation

During 2020–23, Canadian banks were temporarily exempted from using settlement balances in their leverage ratio formulas.³¹ This led to relief for the banks in terms of the amount of capital they need to hold, despite the growing balance sheets due to quantitative easing (QE). A similar measure can be temporarily implemented as a relief from CBDC.

In the situation when CBDC exposure grows above the amount of settlement balances in the economy, the Bank of Canada may need to create additional settlement balances, similar to the process of QE. However, unlike the QE, the settlement balances will not stay on the banks' balance sheets and will eventually be transferred to CBDC accounts. If the central bank chooses to inject the settlement balances into the banking system in advance, as a preparation for CBDC deployment, the banks may end up with elevated settlement balances. In this case, the **decision can be made to temporary remove settlement balances from the leverage ratio.**³²

Despite this measure being effective, our stress exercise suggests that the need for it is minimal. The starting leverage ratios of DSIBs in our scenario remain at an average of 4.8%. Under severe stress and CBDC, the ratios drop to an average of 3.9% during the worst quarter of the scenario and 4.7% during the final quarter of the scenario, which is significantly above the official regulatory limit.

Conclusion

Based on the findings presented in this note, we conclude that during a severe but plausible recession, the introduction of a CBDC would have only a mild impact on Canada's six largest banks. The effects on regulatory ratios would be close to zero, primarily because DSIBs prioritize compliance with regulatory standards and can find alternative ways to absorb CBDC-related losses. The importance of maintaining capital ratios becomes particularly evident under very severe stress, when the risk-weighted capital ratios of DSIBs approach or fall below regulatory limits.

Nevertheless, the impact of CBDC on DSIBs would still materialize—mainly through profitability and balance sheet growth. CBDC adoption would require banks to shift their funding mix toward more

³¹ See Office of the Superintendent of Financial Institutions (2022b).

³² If repo purchases are partially or fully used to “back up” CBDC, similar changes can be applied to repo in the leverage formulas. When doing so, it is important to consider the regulatory arbitrage created by an asymmetric leverage regulation. For instance, as a response to COVID, settlement balances were exempted from the formula in leverage ratio up until April 1, 2023, repo were exempted from leverage ratio up until January 1, 2023. This made bond purchases more favourable for the banks than repo operations at the end of the stress episode. Because regulatory announcements are typically made ahead of time, it might be beneficial to develop a longer-term strategy for how CBDC will be backed up in case of stress, not to provide unnecessary policy relief to the banks.

expensive sources, immediately reducing profitability and slowing capital accumulation over time. To preserve high capital ratios, banks would likely reduce their lending exposures compared with the non-CBDC case. Under a very severe stress scenario, we estimate an average reduction in lending of about 5.5% when CBDC is highly demanded and widely accessible but lacks advanced features (e.g., smart contracts or physical peer-to-peer payments). This reduction would add to the lending contraction that banks already experience during stress, but the combined effects of stress and CBDC remain too small to shrink overall balance sheets. Even under the most adverse shocks, DSIBs continue to grow at a positive rate and maintain strong profitability. Furthermore, the negative effects of CBDC are likely to be offset by the benefits large banks gain from acting as CBDC payment service providers and from broader trends in digitalization—factors not accounted for in this analysis.

Despite the mild overall impact of CBDC on Canadian DSIBs, policy-makers may still choose to support large banks, for example, to sustain lending activity and secure DSIB cooperation in CBDC implementation. To this end, it is advisable to introduce CBDC gradually—over several years—allowing banks sufficient time to adjust their balance sheets with minimal losses. In addition, capital and leverage requirements could be recalibrated to mitigate CBDC-related effects. Liquidity coverage ratio (LCR) requirements would also need to be updated to reflect the increased flightiness of retail deposits. Our results show that even a sudden and significant LCR adjustment would be manageable for banks, though it would prompt a reallocation toward more liquid assets and slower lending growth. To safeguard credit provision, further measures may be needed to strengthen depositor confidence and ensure retail deposits are perceived as stable, thereby reducing banks' need to hold excessive liquid assets as protection against runs.

Given the small estimated effect of CBDC during a severe recession, it has previously been suggested that strict holding limits are unnecessary. Demand for a CBDC without innovative features or integration with bank branches is likely to remain modest, and additional limits could further constrain its use for bill payments and peer-to-peer transactions. However, if CBDC adoption accelerates and fintech competition begins to pose a more significant threat to banks, temporary holding limits could serve as a flexible and effective tool to support financial stability, as we demonstrated in this work.

It is important to note that this analysis addresses only part of the financial stability implications of CBDC. A complementary exercise should be developed to model sudden financial panics and bank runs. Such an exercise would assess whether the central bank could mitigate stress by optimizing liquidity facilities, enhancing bank monitoring, enforcing CBDC limits, and safeguarding bank liquidity. Key vulnerabilities to consider include the digital and instantaneous nature of CBDC transactions, collateral scarcity, and unstable funding conditions.

Finally, future CBDC research should extend to smaller banks with a focus on the heterogeneity of their business models. Many medium-sized and small Canadian banks specialize in narrow product lines (e.g., mortgages, business lending, or foreign exchange) and rely less on demand deposits. Others operate through strategic partnerships or co-branding with large non-financial firms such as retailers. These niche and interdependent business models may make smaller banks less sensitive

to CBDC. In prior analyses, small-bank business models received limited attention; conclusions were instead drawn from aggregate balance sheet compositions, which suggested greater vulnerability among smaller banks. A refined analysis is therefore needed to reassess CBDC's effects across the spectrum of smaller banks.

Appendices

A1. Details of the behavioural model of banks

The dynamic analysis is conducted using the Bank of Canada banking strategy model, which is estimated structurally using DSIBs regulatory data from 2015Q1 to 2022Q4, on a quarterly basis, and thus is **consistent with the historical behaviours of banks**.³³ In each period of the model, bank i maximizes utility function

$$\max_{\text{balance sheet } x_i} E[\text{return on equity}(x_i, x_{-i})] - \lambda \log(\text{regulatory gaps}(x_i, x_{-i})) - \gamma \text{transition costs}(x_i, x_{-i})$$

by choosing the vector of balance sheet exposures x_i given the strategies of other banks x_{-i} and the CBDC scenario.^{34, 35}

Banks are required to meet the minimum **regulatory requirements**. However, they may use their capital or liquidity buffers above these minimum levels as needed to maximize profitability. Despite this flexibility, sudden declines in regulatory ratios expose banks to both regulatory and reputational costs, which have been empirically estimated. In the utility function, regulatory gaps are defined as the distances between the minimum required and the current liquidity, capital or leverage ratios. These gaps are modelled on a logarithmic scale to capture the increasing sensitivity of banks as their ratios approach the regulatory limits.

While banks have the flexibility to adjust both sides of their balance sheets, sudden changes can entail **additional costs** arising from interbank competition and balance sheet adjustments, including charges related to buying or selling assets above or below market value, prematurely terminating lending relationships, or aggressively pursuing new funding at higher costs.

The **behaviour of banks is path dependent**. Following the execution of strategies in a given quarter, banks earn net interest and non-interest income on updated exposures minus credit losses, which results in net income subject to taxes and dividends. Retained earnings are then used to increase capital and update the balance sheet proportionally before advancing to the following quarter.

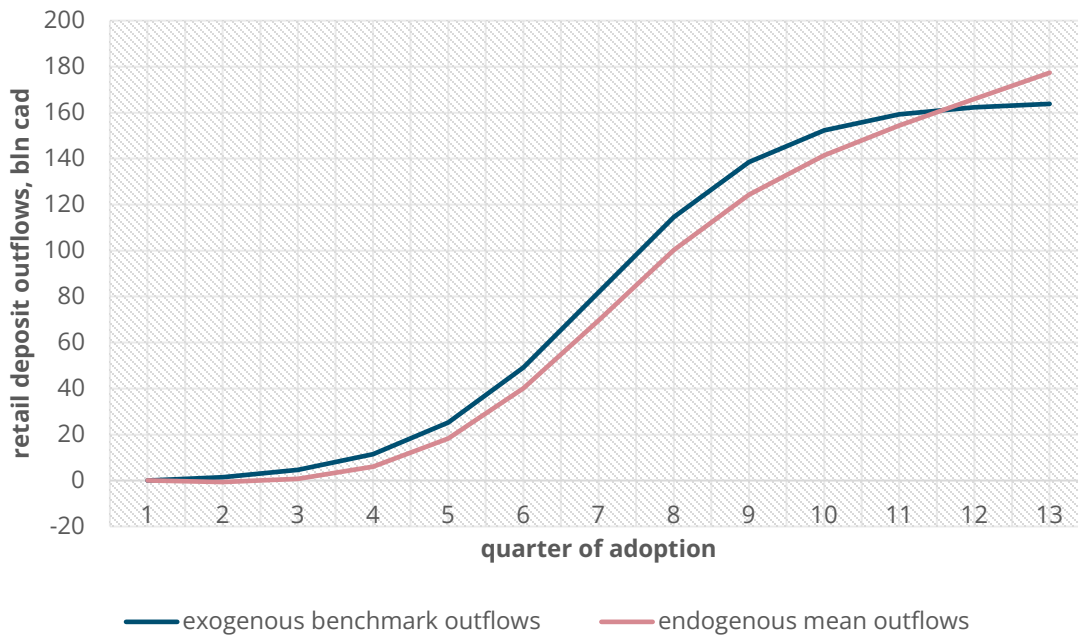
The model captures the **randomness of possible outcomes**, which banks take into account when strategizing. In particular, the realization of the interest income, fees and funding costs is random

³³ The following regulatory reports are consistently modelled: M4 for consolidated balance sheets; BCAR for equity and risk-weighted assets; P3 for income margins and fees; LCR report for liquidity ratios, reports for detailed balance sheets (LRR, A2, N3), etc.

³⁴ Optimized asset categories in x_i and x_{-i} include business loans, mortgages, non-business loans, cash-like assets, government securities, debt holdings, equity holdings, reverse repo; the optimized funding categories in x_i and x_{-i} are retail deposits, corporate term deposits, corporate demand deposits, repo.

³⁵ See [Halaj and Priazhkina \(2021\)](#) for the original version of the banking model and applications. The model has been since enhanced by incorporating reputational/regulatory and transition costs in the utility functions in [Hipp and Ojea-Ferreiro \(forthcoming\)](#).

Chart 11: Retail deposits outflows from DSIBs to CBDC



Note. Red line – benchmark outflows exogenously defined by the CBDC scenario.
 Blue line – endogenous outflows, calculated as the difference in retail deposit exposures between the “no CBDC” and “MOP/SOV CBDC + Fintech” scenarios (outputs of the bank behavioural model, averaged across simulations and aggregated across banks).

Sources: scenario assumptions and simulated model results

and consistent with historical shocks, such that interbank correlations are maintained. Given the empirical distribution of shocks, the banks can assess their expected return on equity for each set of strategies. The convergence to the fixed point is then performed in the competition game to determine the equilibrium strategies for all banks, such that no deviation to a better strategy exists for each bank.

A2. S-curve dynamics of deposit outflows

See Chart 11.

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