

Central Bank Digital Currency and Banking: Macroeconomic Benefits of a Cash-like Design

Jonathan Chiu and Mohammad Davoodalhosseini¹

Bank of Canada

The Future(s) of Money Conference

June 16, 2022

¹The views expressed in this paper are those of the authors and not necessarily the views of the Bank of Canada.

Introduction

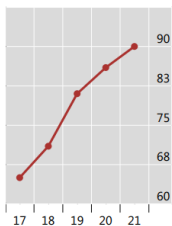
- Many central banks are considering issuing CBDC (BIS, 2021)
 - a digital form of CB money that are widely accessible

Central bank involvement in CBDC work rises further

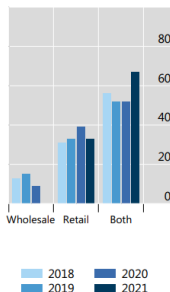
Share of respondents

Graph 1

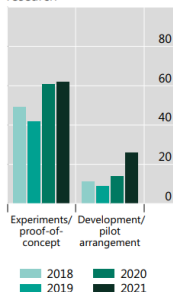
Engagement in CBDC work



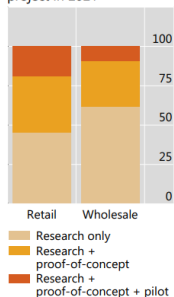
Focus of work¹



Type of work in addition to research¹



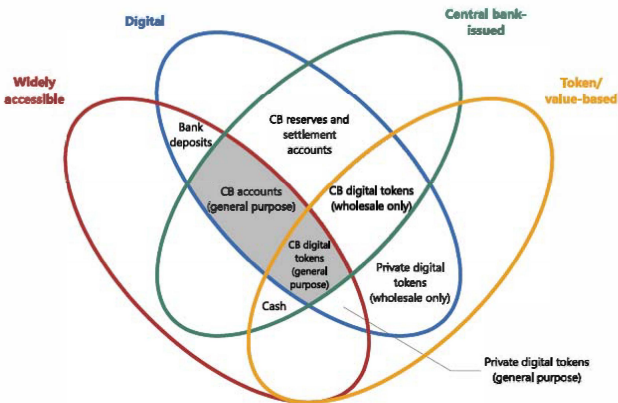
Focus of work by CBDC project in 2021



¹ Share of respondents conducting work on CBDCs.

Introduction

- Many central banks are considering issuing CBDC (BIS, 2021)
 - a digital form of CB money that are widely accessible



The Venn diagram illustrates the four key properties of money: *issuer* (central bank or not); *form* (digital or physical); *accessibility* (widely or restricted); and *technology* (account-based or token-based). CB = central bank. *Private digital tokens (general purpose)* include cryptocurrencies, such as Bitcoin. For examples of how other forms of money may fit in the diagram, please refer to the source.

Introduction

- A policy concern is bank **disintermediation**
 - CBDC is a substitute for bank deposits as payment instruments
 - Raises bank funding cost and reduces lending

Introduction

- A policy concern is bank **disintermediation**
 - CBDC is a substitute for bank deposits as payment instruments
 - Raises bank funding cost and reduces lending
- BIS (2018):
 - \... a flow of retail deposits into a CBDC could lead to a **loss of low-cost and stable funding** for banks... Banks could try to prevent a loss of deposits by raising interest rates or seek funding to replace such out flows,..., which would likely be more costly.

Introduction

- A policy concern is bank **disintermediation**
 - CBDC is a substitute for bank deposits as payment instruments
 - Raises bank funding cost and reduces lending
- BIS (2018):
 - \... a flow of retail deposits into a CBDC could lead to a **loss of low-cost and stable funding** for banks... Banks could try to prevent a loss of deposits by raising interest rates or seek funding to replace such out flows,..., which would likely be more costly.
- Current literature:
 - Interest-bearing CBDC **disintermediates** banks (Keister & Sanches, 2021)
 - ... unless banks have **market power** (Andolfatto, 2020; Chiu et al., 2019)

Introduction

- A policy concern is bank **disintermediation**
 - CBDC is a substitute for bank deposits as payment instruments
 - Raises bank funding cost and reduces lending
- BIS (2018):
 - \... a flow of retail deposits into a CBDC could lead to a **loss of low-cost and stable funding** for banks... Banks could try to prevent a loss of deposits by raising interest rates or seek funding to replace such out flows,..., which would likely be more costly.
- Current literature:
 - Interest-bearing CBDC **disintermediates** banks (Keister & Sanches, 2021)
 - ... unless banks have **market power** (Andolfatto, 2020; Chiu et al., 2019)
 -) **CBDC disintermediates banks in a competitive setting**

This Paper

- Revisit this question in a competitive setting:
 - Does CBDC necessarily disintermediate banks?
 - How does the answer depend on the CBDC design?

This Paper

- Revisit this question in a competitive setting:
 - Does CBDC necessarily disintermediate banks?
 - How does the answer depend on the CBDC design?
- Incorporate two realistic considerations into the model:
 1. Cash and deposits **compete directly** in some transactions
 2. Banks help **nance** the production of consumption goods traded in retail markets.

This Paper

- Revisit this question in a competitive setting:
 - Does CBDC necessarily disintermediate banks?
 - How does the answer depend on the CBDC design?
- Incorporate two realistic considerations into the model:
 1. Cash and deposits **compete directly** in some transactions
 2. Banks help **nance** the production of consumption goods traded in retail markets.
- Main findings:
 - CBDC can **crowd in** bank intermediation even in a competitive setting
 - A **\cash-like"** design is more effective than a **\deposit-like"** one.

Related CBDC Literature

- **Banking**

- e.g., ... Garratt and Zhu (2021), Schilling et al. (2020, 2021), Niepelt (2020), Williamson (2020, 2021), ...

- **Financial stability**

- e.g., Fernandez-Villaverde et al. (2020), Schilling et al. (2020), Keister and Monnet (2020), Williamson (2020)...

- **Digital currency competition**

- e.g., Benigno et al. (2021), Brunnermeier and Payne (2021), Chiu and Wong (2021), Cong and Mayer (2022) ...

- **Monetary policy**

- e.g., Barrdear and Kumhof (2021), Assenmacher et al. (2022), Davoodalhosseini (2021) ...

- **Digital currency design**

- : e.g., Chiu and Wong (2016), Chiu and Koepl (2019), Kahn et al. (2022) ...

Sketch of the Model

Sketch of the Model

- Lagos-Wright structure with rotating markets: Day (DM) and night (CM)
- Infinite horizon $t = 1, 2, \dots$
- HHs:
 - supply labor to firms
 - purchase consumption using different payment instruments
- Firms:
 - hire labor to produce consumption good sold to HHs in a competitive market
 - production financed by banks
- Banks:
 - fund projects by creating deposits
 - deposits used by HHs for payment

Three Types of DM Transactions

- type-1: accept only cash (e.g., off-line)
- type-2: accept only deposits (e.g., online)
- type-3: accept all (e.g., typical stores)

	cash	deposits
type 1	×	
type 2		×
type 3	×	×

Three Types of DM Transactions

- type-1: accept only cash (e.g., off-line)
- type-2: accept only deposits (e.g., online)
- type-3: accept all (e.g., typical stores)

	cash	deposits
type 1	×	
type 2		×
type 3	×	×

- The model is similar to Lucas and Stokey (1987) in this respect.
- We also added “credit” in the generalized model for matching data.

Three Types of DM Transactions

- type-1: accept only cash (e.g., off-line)
- type-2: accept only deposits (e.g., online)
- type-3: accept all (e.g., typical stores)

	cash	deposits	cash-like cbdc	deposit-like cbdc
type 1	×		×	
type 2		×		×
type 3	×	×	×	×

Three Types of DM Transactions

- type-1: accept only cash (e.g., off-line)
- type-2: accept only deposits (e.g., online)
- type-3: accept all (e.g., typical stores)

	cash	deposits	cash-like cbdc	deposit-like cbdc
type 1	×		×	
type 2		×		×
type 3	×	×	×	×

- Unlike deposits, a cash-like CBDC can be used in type 1 transactions.
- Unlike cash, a cash-like CBDC is interest-bearing.

Household Decision in DM

A consumer with cash Z and deposits D solves

$$\max_{c_i, Z^\theta, D^\theta, f} \sigma \left[\sum_{i=1}^3 u_i(c_i) + W(Z^\theta + D^\theta) \right] + (1 - \sigma)W(Z + D)$$

subject to:

$$\begin{aligned} \text{cash} : Z^\theta + (c_1 + f c_3)p &= Z \\ \text{deposits} : D^\theta + [c_2 + (1 - f)c_3]p &= D \end{aligned}$$

c_1 : e.g., farmers' market

c_2 : e.g., Amazon

c_3 : e.g., typical stores

σ : iid consumption shock

W : continuation value function

f : cash fraction of type 3 transactions

Household Decision in DM

A consumer with cash Z and deposits D solves

$$\max_{c_i, Z^0, D^0, f} \sigma \left[\sum_{i=1}^3 u_i(c_i) + W(Z^0 + D^0) \right] + (1 - \sigma)W(Z + D)$$

subject to:

$$\begin{aligned} \text{cash} &: Z^0 + (c_1 + f c_3)p && Z \\ \text{deposits} &: D^0 + [c_2 + (1 - f)c_3]p && D + B \end{aligned}$$

c_1 : e.g., farmers' market

c_2 : e.g., Amazon

c_3 : e.g., typical stores

σ : iid consumption shock

W : continuation value function

f : cash fraction of type 3 transactions

Firm Decision

- A firm borrows from banks to finance production

Given (p, R_ℓ) , solve:

$$\max_k [pF(k) - R_\ell k]$$

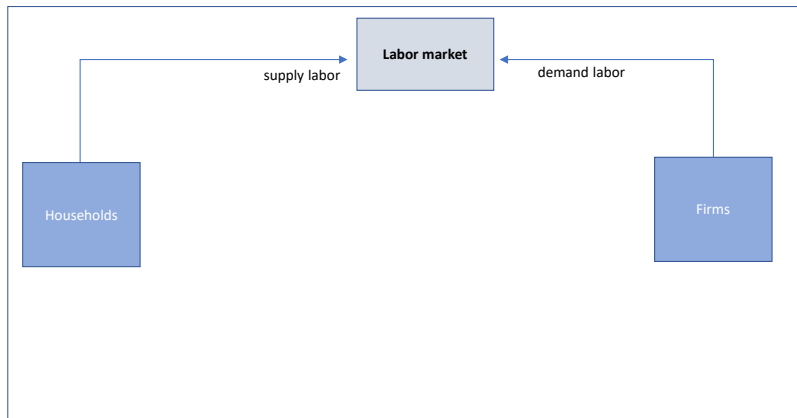
Equilibrium production:

$$pF'(k) = R_\ell (= R_d)$$

- Goods market clearing:

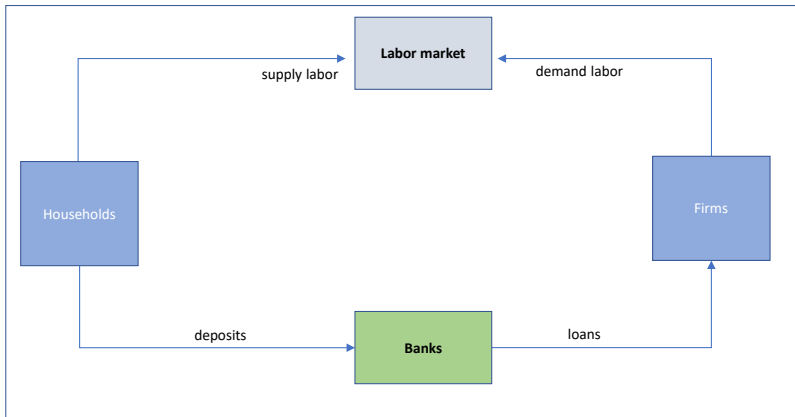
$$F(k) = \sigma(c_1 + c_2 + c_3)$$

Overview of the Model



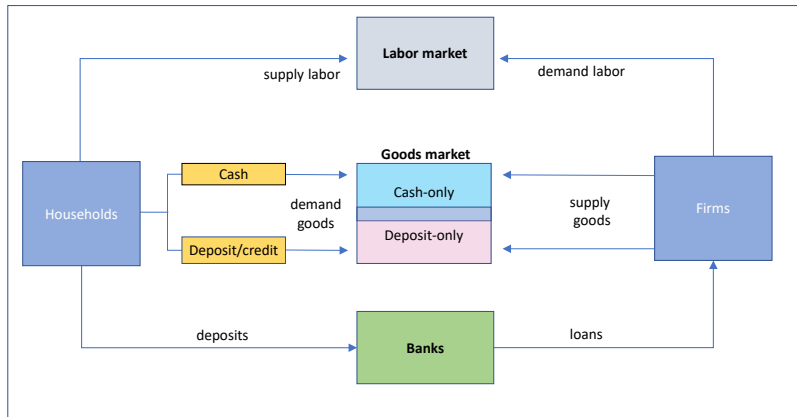
To produce, firms hire labor from HHs ...

Overview of the Model



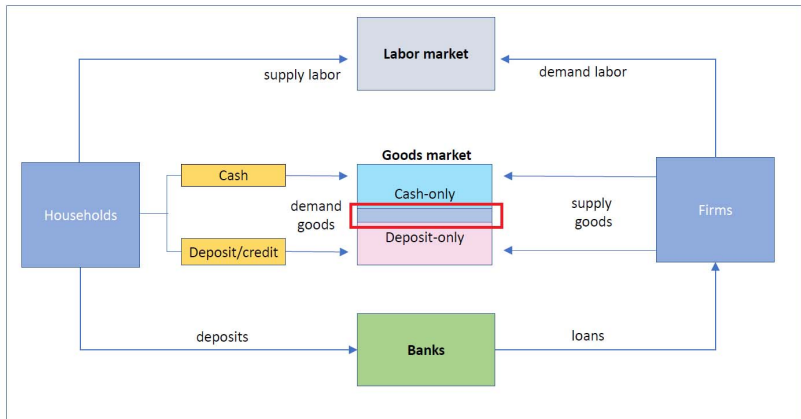
Firms are funded by deposit-taking banks

Overview of the Model



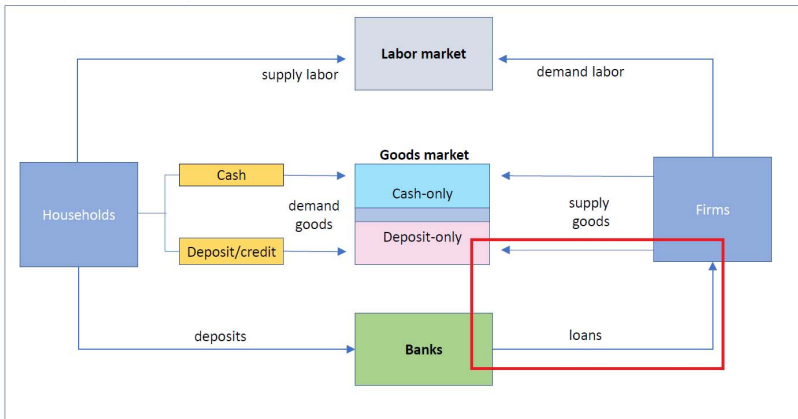
To buy goods from firms, HHs use deposits, cash, credit and CBDC

Overview of the Model



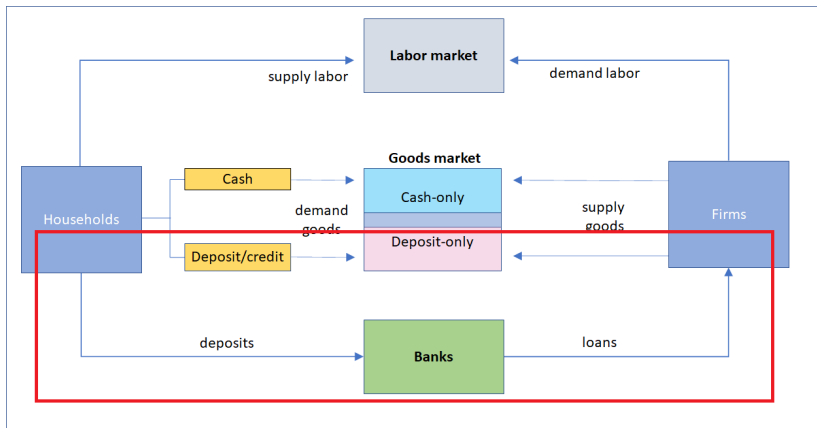
Key feature 1: Direct competition between cash and deposits

Overview of the Model



Key feature 2: Feedback effects from transactions to deposits creation

Overview of the Model



Unique feature: asset and liability sides are connected in the goods market

Introduction
○○○○○

Model
○○○○○○○○○○○○○○

Findings
●○○○○○○○○○○○○

Conclusion
○○○

Appendix
○

Findings

Qualitative Findings

If CBDC and deposits are both used in some transactions (type-3):

- A cash-like CBDC can **crowd in** bank intermediation and promote consumption, investment and welfare.
- A cash-like CBDC is **more effective** than a deposit-like CBDC.

Effects of Cash-like CBDC

Proposition

A higher interest rate paid on a cash-like CBDC leads to higher c_1 , c_2 , and c_3 , k and welfare.

Cash-like CBDC ($f \geq (0, 1)$)	c_1	c_2	c_3	c
- Payment efficiency	+	+	+	+
- Price effects				
- Bank funding effects				
Total effects	+	+	+	+

Intuition: Cash-like CBDC promotes banking and welfare

Interest-bearing Cash-like CBDC

- 1 Opportunity costs of holding cash-like balances #
 - HHs buy more goods in cash-related transactions (type 1 & 3)
 - Induces banks to pay higher deposit rates (**competition**)
 -) HHs buy more goods in non-cash transactions too (type 2)
- 2 Higher goods demand induces banks to create more deposits to finance production (**feedback**)
- 3 Higher interest raises banks' funding costs (disintermediation)

Overall: Positive effects outweigh the negative ones, leading to higher consumption, banking and welfare.

Effects of Deposit-like CBDC

Proposition

A higher interest rate paid on a deposit-like CBDC leads to a higher c_2 and c_3 , but a lower c_1 .

Deposit-like CBDC	c_1	c_2	c_3	c
- Payment efficiency	0	+	+	+
- Price effects				
- Bank funding effects				
Total effects		+	+	+/

Intuition: Deposit-like CBDC has weaker effects

Interest-bearing Deposit-like CBDC

- 1 Opportunity costs of holding deposit-like balances #
 - HHs buy more goods in deposit-related transactions (type 2 & 3)
 - ~~Induces cash to pay higher interest rates (competition)~~
 -) ~~HHs buy more goods in cash transactions (type 1)~~
- 2 Higher goods demand induces banks to create more deposits to finance production (feedback)
- 3 Higher interest raises banks' funding costs (disintermediation)

Overall: Positive effects are weaker, and CBDC may increase or decrease consumption, banking and welfare.

Calibration

- Functional forms

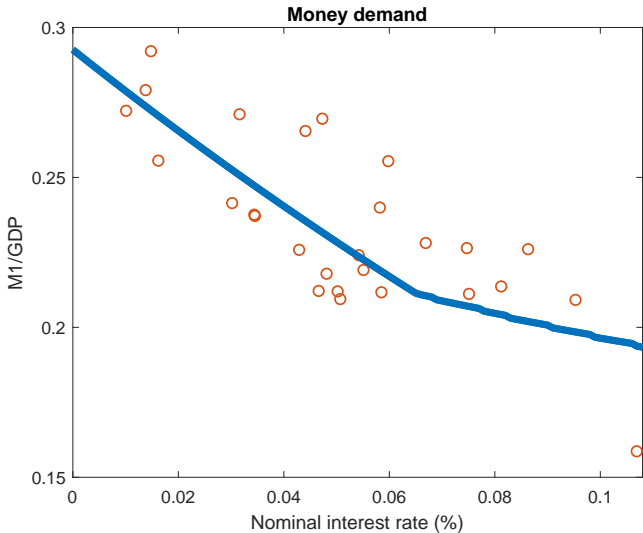
$$\text{CM utility} : A \log(X)$$

$$\text{DM utility} : u_i(c_i) = \frac{\omega_i}{1 - \frac{1}{\xi}} c_i^{\frac{1}{\xi}}$$

$$\text{Production} : F(k) = \frac{k^{1-\gamma}}{1-\gamma}$$

- Fix $\beta = 0.97$, $\mu = 2\%$, and normalize $\sum \omega_j^\xi = 1$.
- Choose parameter values:
 - (ω_i, γ) to match payments data
 - (ξ, A) to match money demand curve
 - (σ, B) to minimize distance btw data and model at 2% in ation
- US data sources:
 - Money demand data by Lucas-Nicolini (2015)
 - Cash, credit, debit and consumption shares from Diary of Consumer Payment Choice 2018

Calibration using Money Demand Data



Calibration using Payment Survey Data

	Data	Model
Cash share of transactions	18%	$\frac{Z}{Z+D+B}$
Debit share of transactions	39%	$\frac{D}{Z+D+B}$
Type 1 share of transactions	15%	$\frac{c_1}{c}$
Type 2 share of transactions	13%	$\frac{c_2}{c}$

ω_i 's are constructed so that c_i 's are matched exactly. Other targets are matched with less than 1 pp error.

Summary of Parameter Values

Parameters	Notation	Value	Notes
Calibrated externally			
Discount factor	β	0.97	Standard
Productivity of good- i producers	a_i	1	Normalization
Money growth rate	μ	1.02	2% inflation
Calibrated internally			
Curvature of production	γ	0.165	Payment data
Coefficient of type 1	ω_1	0.606	Payment data
Coefficient of type 2	ω_2	0.587	Payment data
Coefficient of type 3	ω_3	0.916	Payment data
Coeff. of PM consumption	A	1.617	Money demand
One minus elasticity inverse	ξ	3.800	Money demand

Results: Cash-like CBDC

Decomposition at 5% rate

Percentage change	c_1	c_2	c_3	c
- Bank funding effects	12.10	12.99	12.99	12.99
- Payment efficiency	48.64	48.64	48.64	48.64
- Price effects	23.04	23.04	23.04	23.04
Total effects	12.61	12.61	12.61	12.61

- bank funding effect is negative
- improve payment efficiency for type 1 and 3 transactions
- ... spill over to type 2 (endogenous bank rate responses)
- ... dominating the price effects
- Overall effect: **raise consumption and crowd-in banking**
- CBDC market share reaches 25%

Results: Deposit-like CBDC

Decomposition at 5% rate

Percentage change	c_1	c_2	c_3	c
- Bank funding effects	8.31	12.16	12.16	20.58
- Payment efficiency	0.00	46.31	46.31	39.38
- Price effects	13.49	19.74	19.74	18.81
Total effects	21.80	14.41	14.41	8.99

- bank funding effect is negative
- improve payment efficiency only for type 2 and 3 transactions
- ... no spill over to type 1
- ... dominating the price effects
- Overall effect: raise consumption and crowd-in banking, but **less than those for cash-like CBDC**
- CBDC market share reaches 13%

Conclusion

- Ignoring all other benefits (e.g., privacy, safety), we show that CBDC can still improve welfare and crowd-in banking even when banks have **no market power**
- Important to incorporate **GE feedback** neglected by the literature

Conclusion

- Ignoring all other benefits (e.g., privacy, safety), we show that CBDC can still improve welfare and crowd-in banking even when banks have **no market power**
- Important to incorporate **GE feedback** neglected by the literature
- Design matters: a cash-like CBDC is more effective for improving intermediation, consumption, and welfare.
- To realize the potential benefits:
 - The CBDC can serve the current market segments where
 - cash is the only option (e.g., off-line)
 - cash competes directly with deposits (e.g., PoS)
 - The CBDC can bear interest (or other perks) to reduce the opportunity costs of holding payment balances

Extensions and Future Work

Some Extensions:

- Demand side:
 - General CES preferences
- Supply side:
 - General production function
- Banking:
 - Financially constrained banks
 - Introducing unbanked households
- Calibration:
 - Different sample periods
 - Explored micro payment survey data

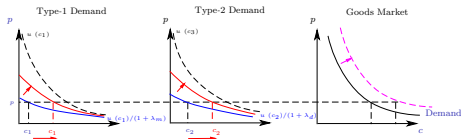
Future work:

- Other sources of funding
- Endogenous payment acceptance

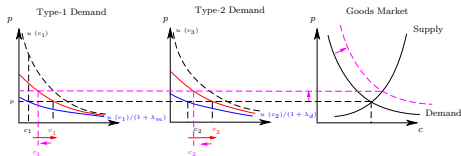
Thank you!

Decomposition

Payment efficiency



Price channel



Bank funding costs

