Central Bank Digital Currency and Monetary Policy

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Presentation at the *Economics of Digital Currencies* Conference

October 7, 2020

Disclaimer: The views expressed in this paper are solely those of the author and no responsibility for them should be attributed to the Bank of Canada.

Introduction

- Large interest in possibility of introducing CBDC
  - Money issued by CB in digital format for retail transactions

- Even if CBDC is introduced, cash expected to be around:
  - *"Some economists advocate that the central bank should replace cash with a digital currency that can be given a negative interest rate. ... I would once again like to say that the Riksbank has a statutory requirement to issue banknotes and coins. I see e-krona primarily as a complement to cash."*

    Cecilia Skingsley, Deputy Governor of the **Riksbank**, 2016
  - "*In its role as the provider of Canadian bank notes, the Bank is working to ensure the processing and distribution of these notes is as efficient as possible. This will help make certain that cash remains a viable method of payment well into the future, ...*"

    Contingency Planing for a CBDC, **Bank of Canada**, 2019

What I Do

I study optimal monetary policy in the presence of cash and CBDC:

- CBDC:
  - Allows transfers contingent on balances
  - Fixed cost of carrying for agents: e.g., cost of losing anonymity
- Cash:
  - Contingent transfers NOT allowed; only lump sum subsidies
  - ZERO cost

Main Results

- If CBDC is not too costly, it is a better tool for MP:
  - First best is achievable
  - Cross-subsidization is possible
- **Co-existence** scheme, compared with **cash-only** and **CBDC-only** schemes, is **often sub-optimal** even if the first best requires usage of cash for some buyers and CBDC for others
  - With co-existence, cash provides an **outside option** for agents
- If CBDC is about 0.25% more costly than cash, then CBDC leads to 0.12% increase in consumption for the US

Other Results

Literature Review

- **New Monetarist:** Lagos and Wright (2005), Lagos and Zhang (2018), Rocheteau and Wright (2005), Zhang (2014), Gu, Mattesini, and Wright (2016)
- **Broadly related:**
  Rogoff (2016): Removing cash
  Andolfatto (2010): Interest-bearing money
  Chiu and Wong (2015): Mechanism design approach
  Barrdear and Kumhof (2016): Quantitative analysis
  Zhu and Hendry (2017): CB money and private money
  Kahn, Rivadeneyra and Wong (2018): Discussion
- **CBDC and banking**: Keister and Sanches (2018), Chiu, Davoodalhosseini, Jiang and Zhu (2019), Andolfatto (2019)

Outline

- Model
- Benchmark results: costless CBDC
- Costly CBDC
- Privacy
- Calibration

Model

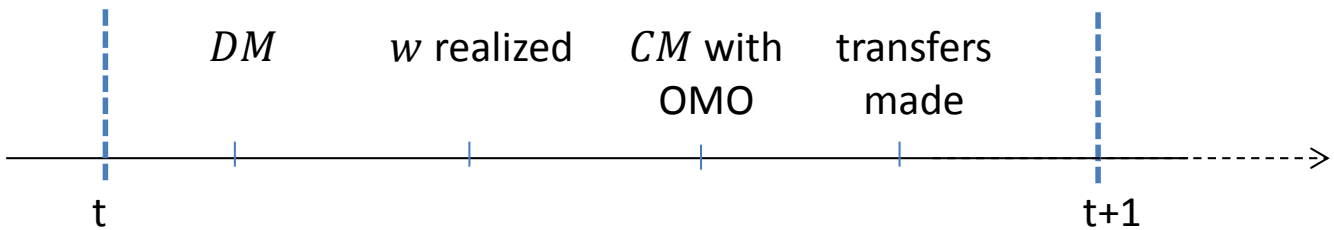
Lagos-Rochetaue-Wright structure

- Discrete time $t = 1, 2, ...$, discount factor $\beta \in (0, 1)$
- Random meetings in DM w. prob. σ
- Proportional bargaining with θ being buyer's bargaining power
- Measure 1 of sellers and heterogeneous buyers
  - DM production cost: $c(q)$
  - DM utility: $wu(q)$ where $w \sim F$ over $[w_L, w_H]$, iid across time and individuals
  - First-best level:

$$q_w^* = \arg\max_q \{wu(q) - c(q)\}$$

Model

- Two means of payments, cash and CBDC
  - CBDC holdings are observable while cash holdings are not
    - CBDC transfers: $t_e(z_e, w) \in \mathbb{R}_+$
    - Cash transfers: $t_c \in \mathbb{R}_+$
  - Cost of carrying CBDC from CM to DM is $K \geq 0$; for cash, it's 0
- Focusing on steady state equilibrium, the planner maximizes welfare by choosing: $\{\gamma_c, \gamma_e, t_c, \{t_e(z, w)\}\}$



Costless CBDC

- FB cannot be achieved with cash as taxation on cash is not possible

Proposition

Assume $K = 0$. First Best (FB) is achievable with CBDC iff

$$\beta\sigma\theta \int (wu(q_w^*) - c(q_w^*))dF(w) \geq (1-\beta) \int D_w(q_w^*)dF(w)$$

where $D_w(q) \equiv (1-\theta)wu(q) + \theta c(q)$.

- β and θ should be sufficiently high
- CBDC is useful for **cross-subsidization**, e.g., when low-value buyers don't achieve the FB but high-value buyers do

Costless CBDC

- Optimal transfer scheme with homogeneous buyers:

$$t_e(z_e, w) = \begin{cases} -\frac{1-\beta}{\beta} D_w(q_w^*) + (\frac{\gamma_e}{\beta} - 1) z_e & z_e \geq \frac{D_w(q_w^*)}{\gamma_e} \\ 0 & z_e < \frac{D_w(q_w^*)}{\gamma_e} \end{cases}$$

- Set γ_e high so that the CBDC transfers are positive
- Set γ_c high so that the gains from using cash become 0

Who Uses CBDC?

Proposition

Assume $\frac{wQ''(w)}{Q'(w)} \geq -1$, *where* $Q(w) \equiv \arg\max_q \{wu(q) - c(q)\}$.
If co-existence is optimal, low types use cash and high types use CBDC.

Intuition:

- The gains from CBDC grow faster in w than those from cash
- CBDC cost is independent of types

Optimal Scheme

Suppose there are only two types, w_L w. p. $1-\pi$ and w_H w. p. π.

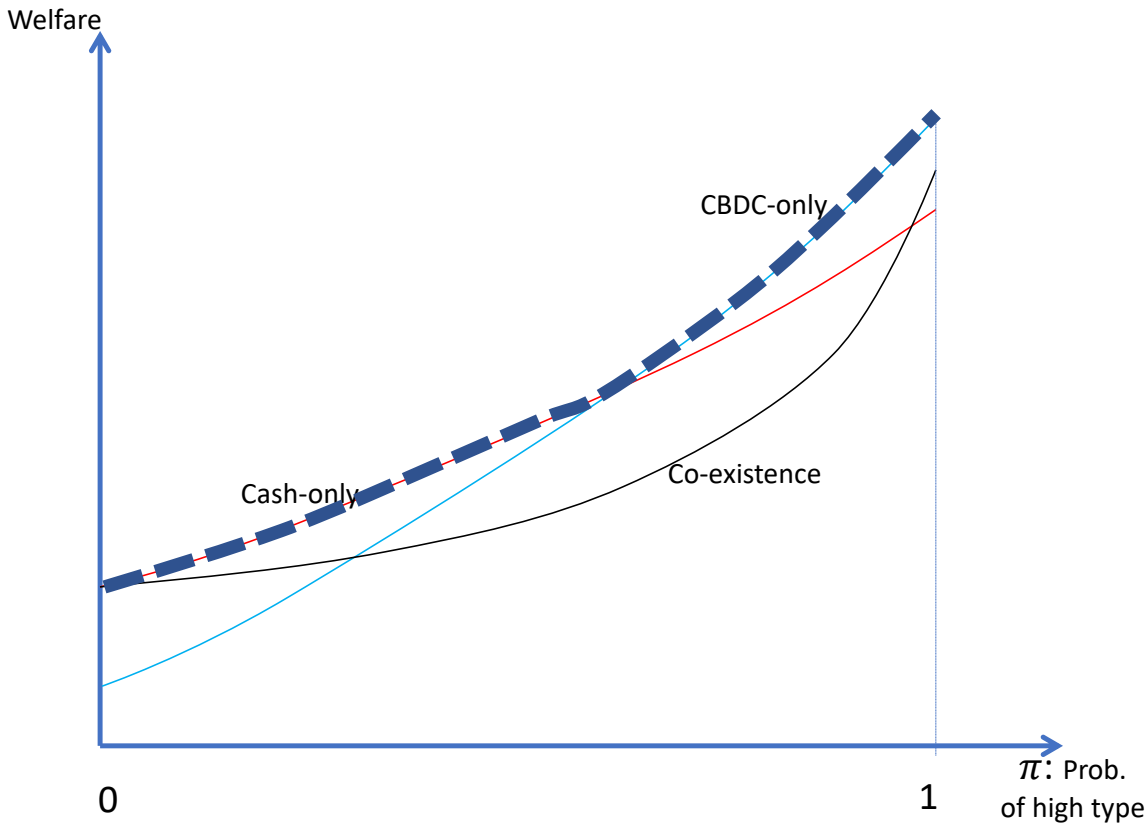
- **Cash-only**: 0 inflation, welfare loss due to opp. cost of holding cash
- **CBDC-only**: Less distortion, but direct cost K
- **Co-existence**:
  - Low cash inflation: cash would be a good alternative for high-value users, prompting them to use cash instead
  - High cash inflation: cash users are hurt

Hence, availability of cash poses a limit on the gains that can be achieved by CBDC

Proposition

*Under certain parameter restrictions, the **co-existence scheme is NOT optimal** for π sufficiently close to 1.*

Optimal Scheme

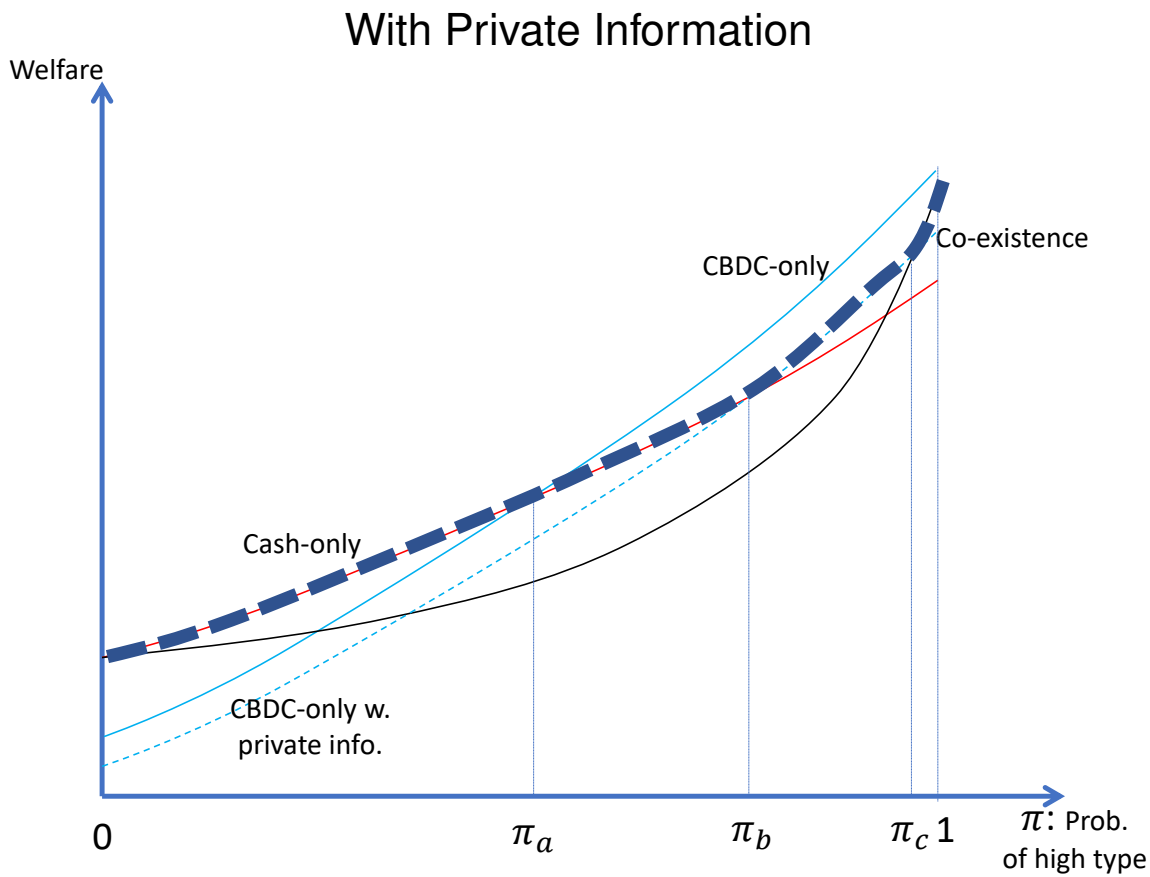


Privacy

- Agents' types cannot be seen/used, so $t_e = t_e(z_e)$ not $t_e = t_e(z_e, w)$
- **Cash-only**: Welfare **unaffected** by private info.
- **CBDC-only:** Welfare is **lower** with private information, because IC_{12} and IC_{21} are present
- **Co-existence:** Welfare **unaffected** by private info.
  - Without privacy, high types may want to use cash, but low types don't want to use CBDC
  - With privacy, low types may want to use CBDC
    - **Shown** that is not binding, **because low types have to bring more money to mimic high types**
    - Not useful, as their marginal utility is less than high types

Privacy

- Co-existence is more likely to be optimal when agents have privacy concerns compared with the case they don't



Calibration

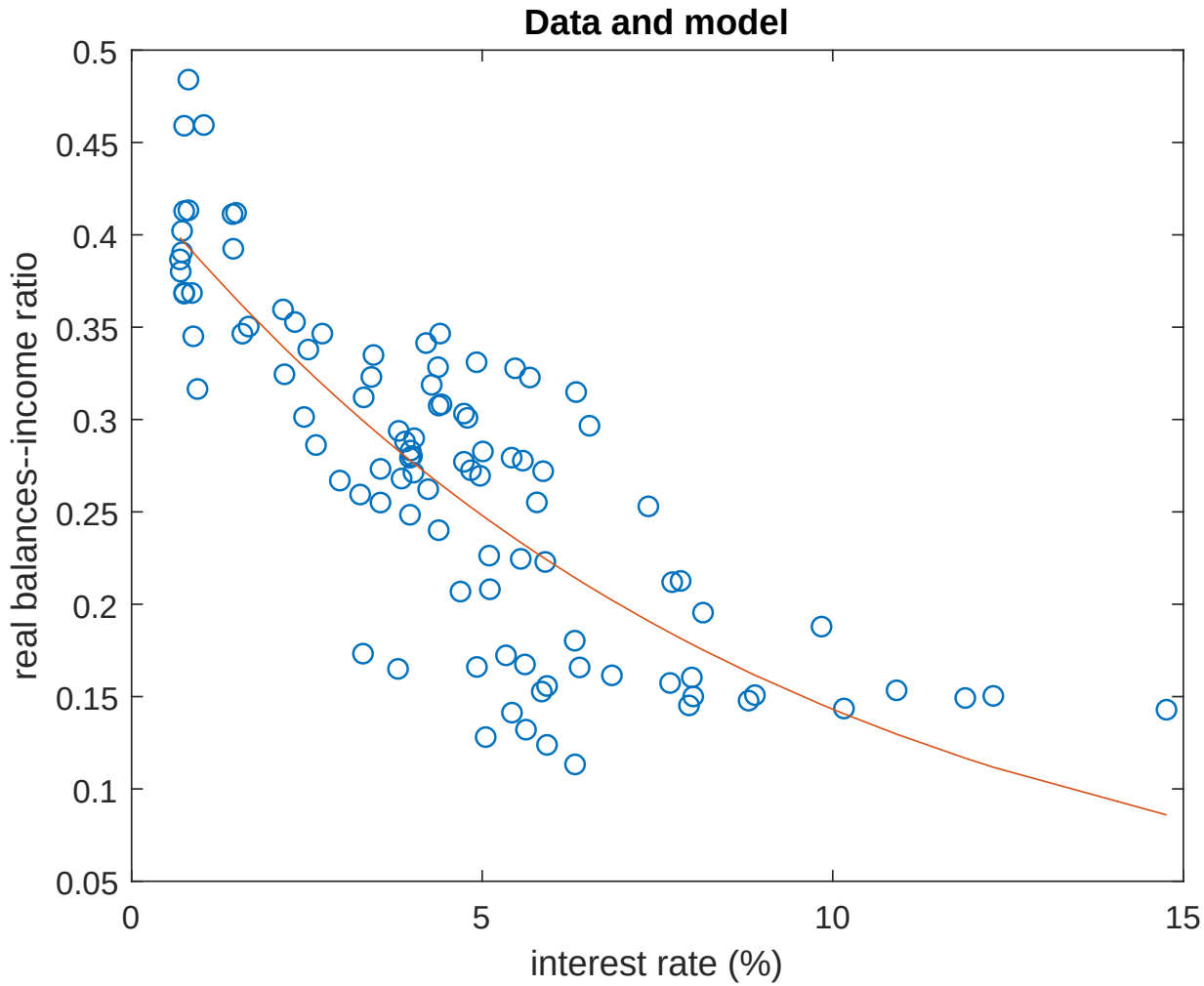
- Functional forms

$$\begin{aligned} \text{CM utility} &: A\log(X) \\ \text{DM utility} &: u(q) = q^{1-\eta} \\ \text{DM cost} &: c(q) = q \end{aligned}$$

- Normalize $(1-\pi)w_L + \pi w_H = 1/(1-\eta)$, fix $\sigma = 0.5$
- Pick parameter values to match empirical targets
- US Data sources:
  - Money demand data by Craig and Rocheteau (2006)
    - Similar results with Lucas and Nicolini (2015)
  - Cash and debit by DCPC 2016

Parameters

Data and Model for the US



Welfare Gains of CBDC

CBDC cost as a fraction of average transaction value (%)	Who uses CBDC?	Welfare gains of CBDC (%)	Welfare gains of CBDC (%) with 20% adoption
0.000	both	**0.250**	0.036
0.278	both	**0.121**	**0.005**
0.841	none	**-0.008**	-0.012

Table:

The gains are calculated relative to an economy with only cash under 0% inflation.

Low adoption: 80% of agents use only cash regardless.

Optimal Scheme

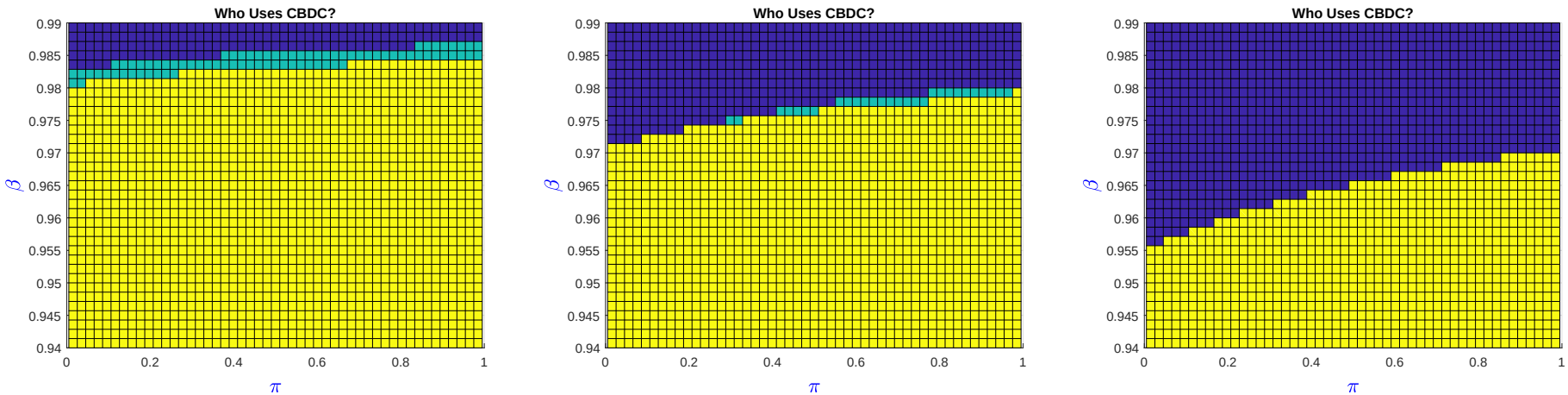


Figure: $K = 0.002$ (left), $K = 0.004$ (middle) and $K = 0.008$ (right).

Yellow: CBDC-only; Green: Co-existence; Blue: Cash-only.

Optimal Scheme

- Co-existence is often sub-optimal
- As π increases, CBDC more likely to be used
- As β increases, cash is more likely to be used, because cash is less costly
- For moderate values of K, as K increases, **co-existence** is less likely to be optimal
  - Higher $K \Rightarrow$ lower welfare under CBDC-only and co-existence schemes, but the effect of a tighter IC constraint is dominant
- Insights robust across alternative calibration parameters

Concluding Remarks

- CBDC is more powerful for MP implementation: e.g., non-linear interest payments and cross subsidization
- Co-existence is often not optimal although the first best choice would require co-existence
- Cash-only and co-existence schemes are more likely to be optimal when agents have privacy concerns compared with the case they don't.

Discussion and Future Work

- Different cost structures:
  - Including storage cost of cash in the model strengthens the results
- Fixed exchange rate ($\gamma_c = \gamma_e$) may be binding given sign restriction on CBDC transfers
- Many things to consider in future work:
  - Endogenous choice of means of payments by agents
  - Potential effects of CBDC on efficiency and stability of financial intermediation
  - GE effects
  - Optimal CBDC policy in presence of other DCs/stablecoins

Other Results

- When **privacy** of agents should be protected, co-existence is more likely to be optimal
- When co-existence is optimal, cash inflation is strictly positive, although running negative inflation is feasible through OMO
- When CBDC is not a perfect substitute for cash, then
  - Co-existence is more likely to be optimal
  - CBDC, together with OMO, helps to achieve the first best even for the meetings in which only cash can be used

Main Results

Calibration Results

Parameters	Var.	Value	Notes
Discount factor	β	0.97	standard in literature
Average markup	μ	20%	under 2% inflation
High/low value	z_H/z_L	2.009	trans val. debit/cash
Fraction of high type	π	0.464	trans. vol. debit/(debit+cash)
Coeff. of type 1 utility	w_L	1.132	
Coeff. of type 2 utility	w_H	1.269	
Coeff. of CM consmp.	A	1.972	money demand curve
Curv. of DM consmp.	η	0.163	money demand curve
B's bargaining power	θ	0.870	money demand curve

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