CBDC and Banks: Threat or Opportunity?

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Motivation

- A CBDC could lead to bank disintermediation, with negative effects on lending (Fernández-Villaverde, Sanches, Schilling, and Uhlig, 2021; Whited, Wu, and Xiao, 2022) and financial stability (Ahnert, Hoffmann, Leonello, and Porcellacchia, 2023).
- If CBDC and bank deposits are perfect substitutes, the central bank can make the CBDC neutral by rechanneling funds back to the banking sector (Brunnermeier and Niepelt, 2019).
- A survey shows that we should expect a heterogeneous adoption of CBDC among households (Bijlsma, van der Cruijsen, Jonker, and Reijerink, 2021).

Does it matter that households have heterogeneous preferences for CBDC? Can banks profit from them?

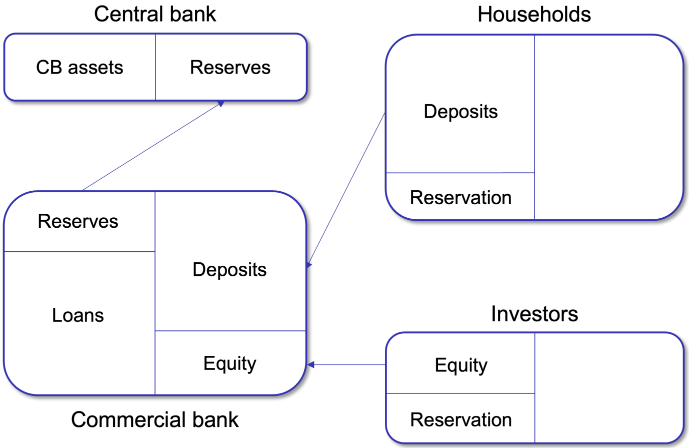
How do banks react? Results snapshot

- Banks use the CBDC to get rid of central bank reserves. Once reserves are exhausted, they start raising interest rates to retain deposits.
- If the central bank rechannels funds back to the banking sector, banks push households towards the CBDC by lowering deposit interest rates.
- A CBDC with no interest rate won't trigger a big response.

Methodology

1. We develop a static model of the banking sector.
2. We calibrate the model.
3. We introduce a CBDC and run counterfactual analyses to study the effects of heterogeneous preferences and central bank rechannelling mechanism.
4. By using survey data from Bijlsma et al. (2021), we calibrate households' heterogeneous preferences to obtain (better) quantitative results.

Model: synopsis



- Static partial-equilibrium model.
- The bank maximizes its profits by choosing the interest rates on deposits and the loans' level of risk.

Model: households

- Deposits: interest rate r^D is optimally decided by the bank.
- Equity: interest rate r^E comes from the bank's profits.
- Outside storage technology: reservation value θ_i is heterogeneous among households and drawn from Θ.

- Households are infinitely risk-averse and compare r^D and θ_i:

$$\max_{x_D, x_\theta, x_E} \min(r^D x_D + \theta_i x_\theta + r^E x_E)$$

- For example, if $\theta_i \sim \mathcal{U}(\underline{\theta}, \overline{\theta})$, the deposits supply is

$$D(r^D) = \int_{\underline{\theta}}^{\overline{\theta}} \mathbb{1}_{\{r^D \geq \theta_i\}} d\Theta = \begin{cases} 0, & r^D < \underline{\theta} \\ \frac{r^D - \underline{\theta}}{\overline{\theta} - \underline{\theta}}, & \underline{\theta} \leq r^D \leq \overline{\theta} \\ 1, & r^D > \overline{\theta} \end{cases}$$

Model: investors

- Deposits: interest rate r^D is optimally decided by the bank.
- Equity: interest rate r^E comes from the bank's profits.
- Outside storage technology: reservation value η_i is heterogeneous among households and drawn from H.

- Investors are risk-neutral and compare r^E and η_i:

$$\max_{x_D, x_\theta, x_E} \mathbb{E}\left[r^D x_D + \eta_i x_\eta + r^E x_E\right]$$

- We exclude the equilibrium with $r^D > r^E$

- The equity demand is

$$\overline{E}(r^E) = \int_{\underline{\eta}}^{\overline{\eta}} \mathbb{1}_{\{r^E \geq \eta_i\}} dH$$

Model: representative bank

- The loans L and reserves M are linked to the amount of deposits D because of the liquidity and capital requirements set by the central bank. Details

- The maximization problem is

$$\max_{r^D,p} \; p\left[L^\alpha + (1+r^M)M - (1+r^D)D\right] - \frac{1}{2}cp^2$$

where

  - p is the probability of success of loans
  - α is the output elasticity of loans
  - r^M is the interest rate on reserves
  - r^D is the interest rate on deposits
  - c is the risk-return payoff of loans

Calibration with US data on 2009–2020

Parameters pinned down from data:

Parameter	Value	Source
Liquidity requirement δ	0.1727	FRED - ratio reserves to deposits
Capital requirement $\underline{\kappa}$	0.0800	FRED - ratio equity to assets
Reserve interest rate r^M	0.0065	FRED - reserve interest rate
Min HH reservation $\underline{\theta}$	0	Default
Min I reservation $\underline{\eta}$	0	Default

Parameters found by matching model outcomes to data:

Parameter	Value	Outcome	Target	Model
Output elasticity α	0.7740	Return on equity	0.0864	0.0818
Risk-return payoff c	0.1460	Loan delinquency rate	0.0352	0.0312
Max HH reservation $\overline{\theta}$	0.0126	Deposit interest rate	0.0072	0.0071
Max I reservation $\overline{\eta}$	1.29	Equity to assets	0.1191	0.1191

Sensitivity

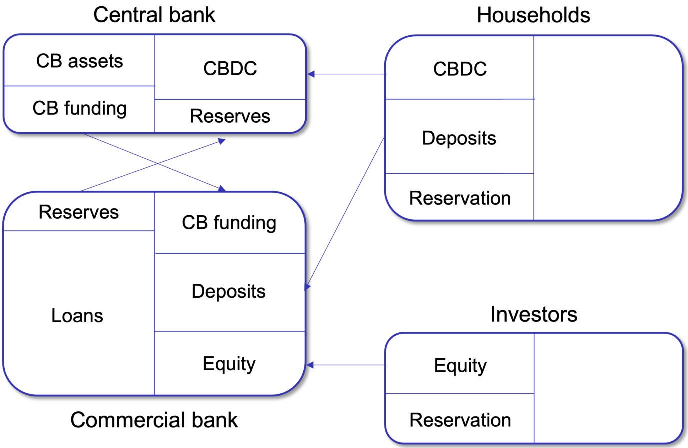
How we introduce a CBDC

- The interest rate r^C is exogenously set by the central bank.
- Households have heterogeneous preferences for CBDC $\gamma_i \sim \Gamma$, expressed as convenience yields on top of r^C.

- Households' choice:
  - ▷ They choose deposits if $r^D \geq r^C + \gamma_i$ and $r^D \geq \theta_i$.
  - ▷ They choose CBDC if $r^C + \gamma_i > r^D$ and $r^C + \gamma_i > \theta_i$.

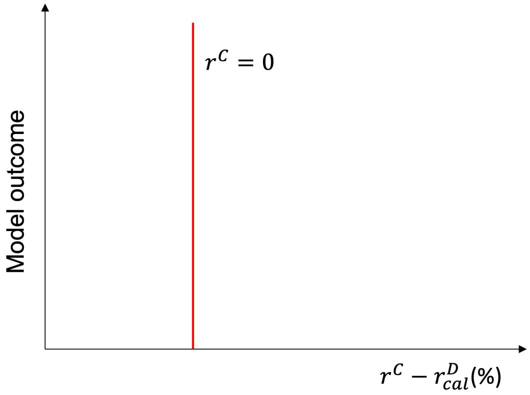
- Bank's possible responses: Constraints
  - ▷ Lose excess reserves (always optimal when possible)
  - ▷ Compete by raising deposit interest rates
  - ▷ Reduce loans
  - ▷ Borrow from the central bank at r^F ← We try different policies!
  - ▷ Collapse

Bank's new maximization problem



$$\max_{r^D, p, F} \; p\left[L^{\alpha} + (1+r^M)M - (1+r^D)D - (1+r^F)F\right] - \frac{1}{2}cp^2$$

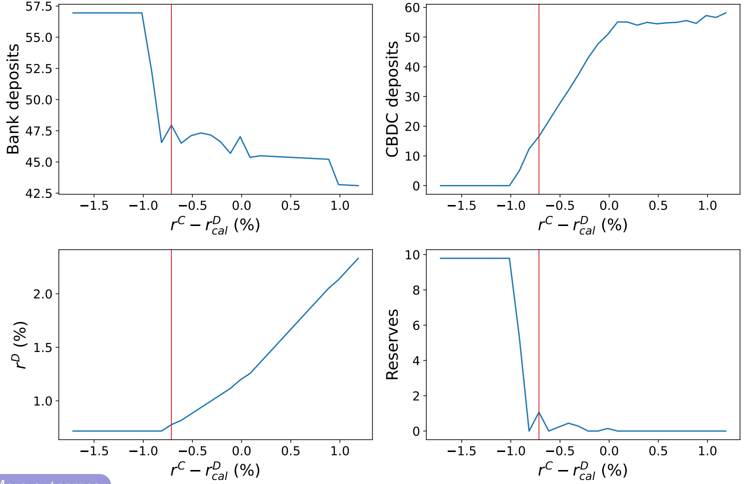
How we present our results



- We fix different r^C and solve the maximization problem.
- The plots summarize the outcomes from the different maximization problems.
- We normalize the maximum amount of deposits to 100.

Effects of heterogeneous preferences for CBDC

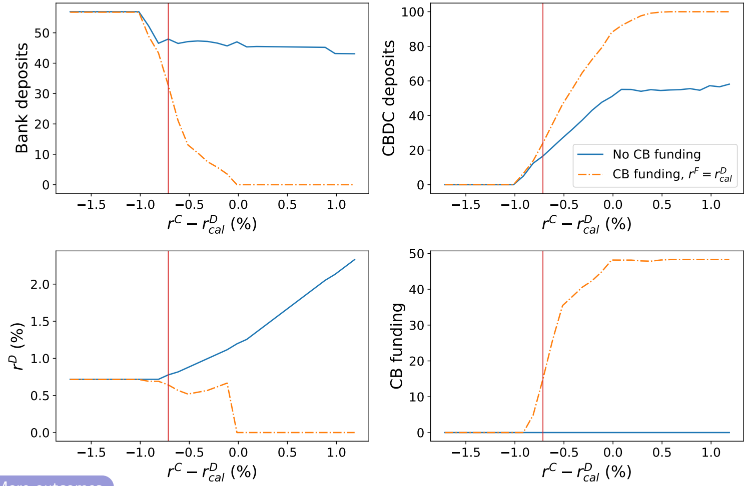
- The heterogeneous preference for CBDC is always positive: $\gamma_i \sim \mathcal{U}(0, 1\%)$
- The bank is not allowed to borrow from the central bank.



More outcomes

Effects of central bank funding

- The heterogeneous preference for CBDC is always positive: $\gamma_i \sim \mathcal{U}(0, 1\%)$
- The bank *can* borrow from the central bank at $r^F = r^D_{cal}$.



More outcomes

What else do we do?

- We run counterfactual analyses with other r^F policies: Results
  - $r^F = r^M$, where r^M is the remuneration on reserves.
  - $r^F = r^C$, where r^C is the CBDC interest rate.
  - $r^F = r^D$, where r^D is the deposit interest rate optimally set with the bank when there is a CBDC.

- Bijlsma et al. (2021) provide survey data on CBDC adoption based on the differential between the CBDC and bank deposits. We use this data to calibrate the distribution of γ_i (i.e., the preference for CBDC) in our model and provide quantitative estimates of banks' response to different CBDC interest rates. Results

Conclusions

- We know from surveys that households have heterogenous preferences for CBDC.
- We develop a static model of the banking sector, calibrate it, and run counterfactual analyses with the introduction of a CBDC.
- We find that banks raise interest rates on deposits only after running out of central bank reserves.
- A central bank policy to rechannel funds back to the banking sector would result in banks reducing interest rates on deposits to push households towards the CBDC.
- With heterogenous preferences calibrated on survey data, we find that a CBDC with no remuneration won't have a big impact on the banking system.

Selected literature

Ahnert, Toni, Peter Hoffmann, Agnese Leonello, and Davide Porcellacchia, 2023, CBDC and financial stability .

Bijlsma, Michiel, Carin van der Cruijsen, Nicole Jonker, and Jelmer Reijerink, 2021, What triggers consumer adoption of cbdc? .

Brunnermeier, Markus K., and Dirk Niepelt, 2019, On the equivalence of private and public money, *Journal of Monetary Economics* 106, 27–41.

Fernández-Villaverde, Jesús, Daniel Sanches, Linda Schilling, and Harald Uhlig, 2021, Central bank digital currency: Central banking for all?, *Review of Economic Dynamics* 41, 225–242.

Whited, Toni M., Yufeng Wu, and Kairong Xiao, 2022, Will central bank digital currency disintermediate banks?, *SSRN Electronic Journal*.

Appendix

Liquidity and capital requirements

Liquidity requirement:

- No distinction between short-term and long-term maturities.
- The liquidity requirement is a constraint on reserves.
- The commercial bank must hold δ of its deposits in reserves at the central bank:

$$M = \delta D$$

- We simplify quantitative easing policies by setting a higher liquidity requirement for banks.

Capital requirement:

- The central bank requires the commercial bank to finance at least $\underline{\kappa}$ of its loans with equity, such that

$$E = \kappa L, \qquad \kappa \geq \underline{\kappa}, \qquad E = \overline{E}$$

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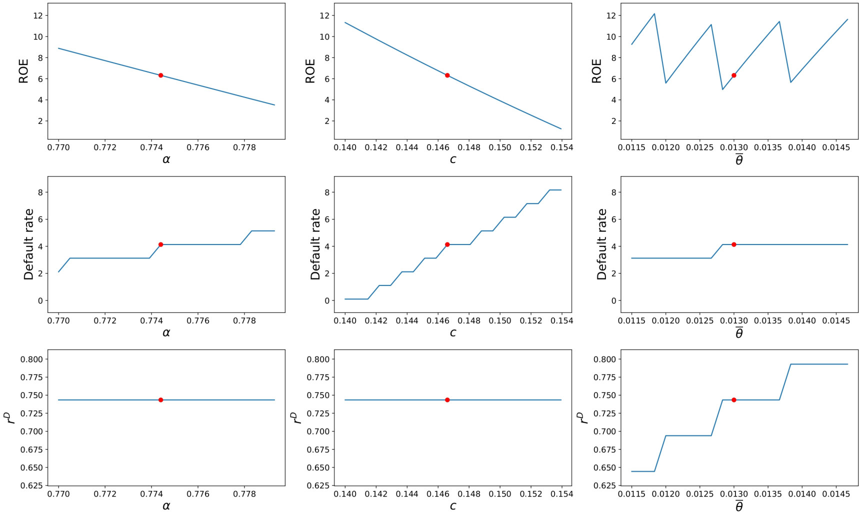
Sensitivity analysis



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Constraints for bank's possible responses

- The bank can reduce its reserves only to compensate the lost in deposits because of the CBDC:

$$\Delta M = \phi \Delta D, \qquad \Delta M \leq C$$

- The central bank can impose a liquidity buffer as a minimum reserve requirement:

$$M \geq \iota D$$

- The central bank does not lend to the bank unless there is an increase in the central bank's size and the bank is liquidity constrained:

$$F \leq \Delta M + C, \qquad \text{when } M = \iota D$$

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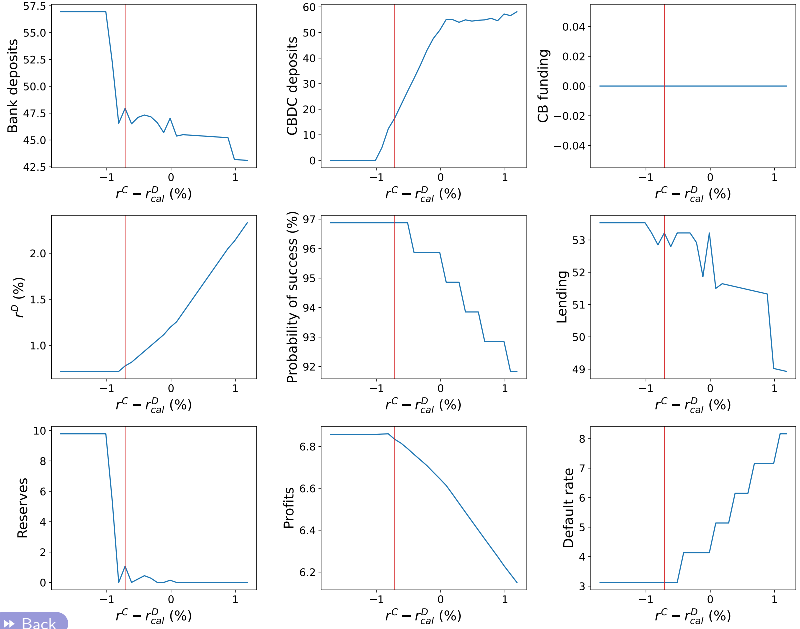
Effects of heterogeneous preferences (more)



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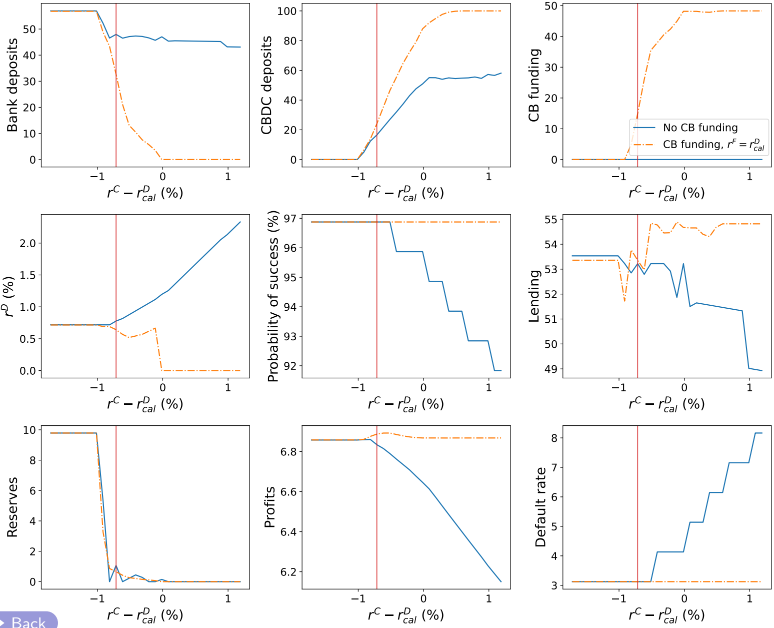
Effects of central bank funding (more)



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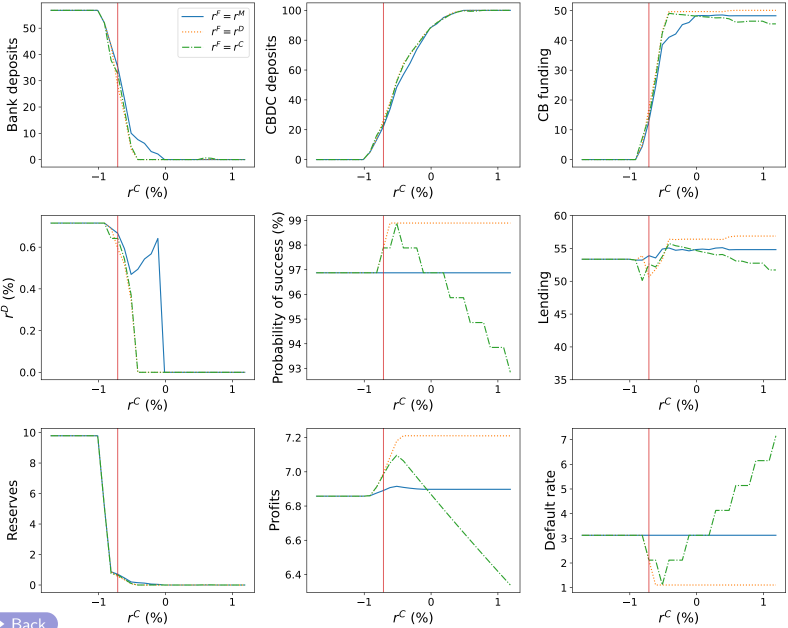
Effects of central bank funding (comparison)



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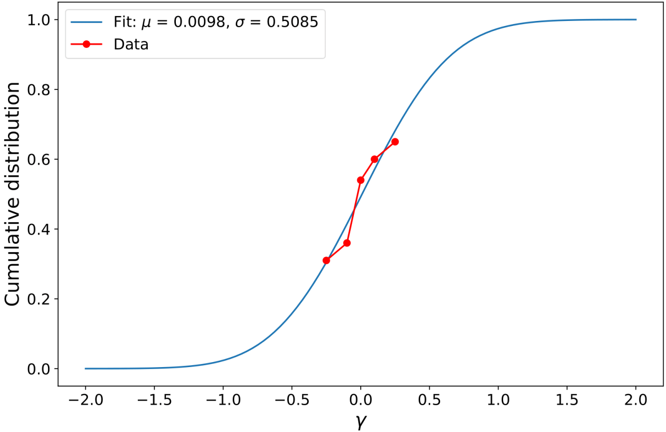
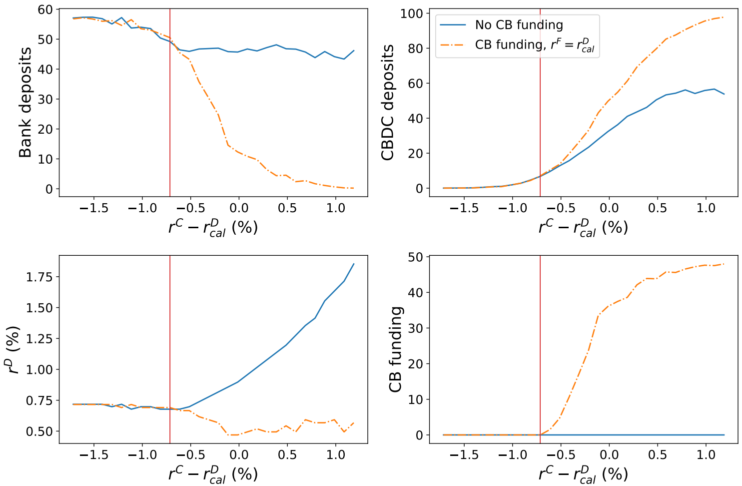
Bijlsma et al. (2021) distribution for preferences

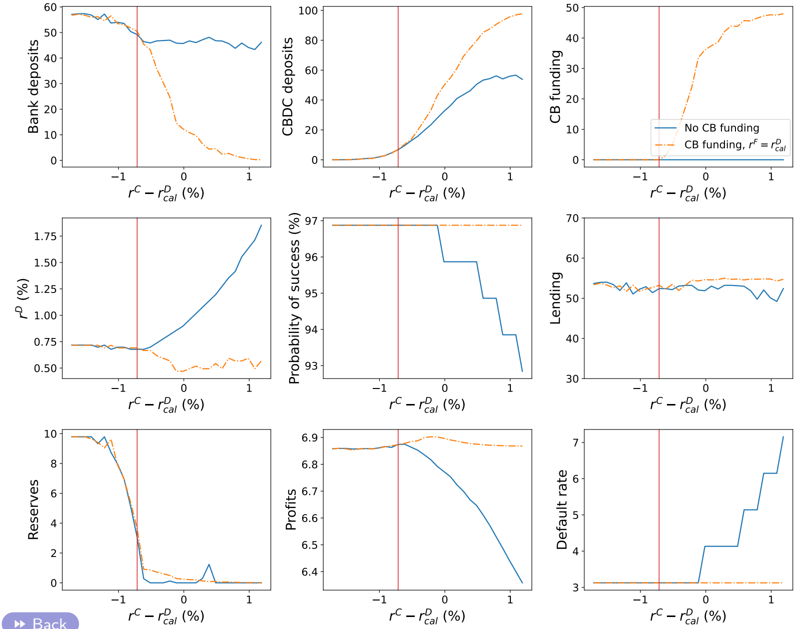


Effects with calibration for preference (more)

- The heterogeneous preference for CBDC is calibrated on the data from the Bijlsma et al. (2021) survey.
- The bank *can* borrow from the central bank at $r^F = r^D_{cal}$.



Effects with calibration for preference (more)



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