

Central Bank Digital Currency and Gresham's Law: An experimental analysis

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Payment system vs monetary system

Introduction

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Payment system

Set of instruments, banking procedures and rules for the interbank transfer of funds designed to ensure the **circulation** of money.

Payment instruments

- Bank cheque
- Debit and credit card
- Online banking
- Mobile payment applications (Wero)

Monetary system

Set of rules and institutions designed to organise the **issuance** of money.

Types of money

- Gold/silver coin
- Bank deposit
- Stablecoin
- Cryptocurrency
- Central bank digital currency (CBDC)

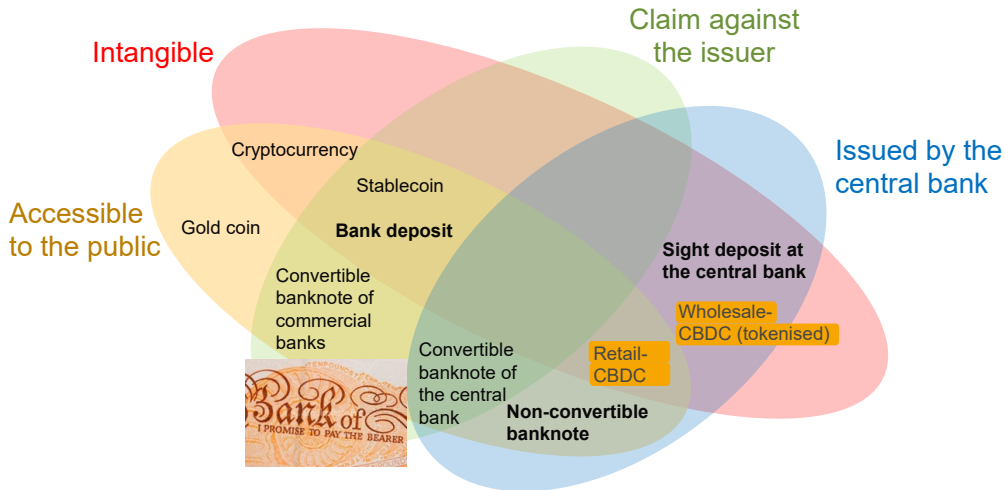
Taxonomy of monies

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Purposes for issuing retail CBDC

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- Providing the public with central bank money, as the use of banknotes is in decline.
- Improving the resilience of payment systems.
- Providing the economy with a cost-effective electronic payment system.
- Promoting diversity and sovereignty of payment systems.

Design options for retail CBDC

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Features **not specific** to CBDC

- Form and technology: account vs token based, cryptographic algorithm, anonymity
- Operational availability: opening hours vs 24/7, online vs offline
- Settlement, execution and payment: gross vs net, instant vs delayed, irrevocable vs revocable
- Convertibility and parity with banknotes and sight deposits
- Interest rate
- Holding limit

Feature **specific** to CBDC

- **No credit risk**

Economic consequences of retail CBDC in the fractional reserve banking system

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Three functions of commercial banks

- Monetary intermediaries (two-tier system)
- Credit providers
- Money issuers (fractional reserve system)

Economic consequences of retail CBDC in the fractional reserve banking system

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Three functions of commercial banks

- Monetary intermediaries (two-tier system)
⇒ CBDC calls into question the raison d'être of banks as monetary intermediaries because CBDC is as convenient as bank deposits but carries no credit risk.
- Credit providers
- Money issuers (fractional reserve system)

Economic consequences of retail CBDC in the fractional reserve banking system

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Three functions of commercial banks

- Monetary intermediaries (two-tier system)
⇒ CBDC calls into question the *raison d'être* of banks as monetary intermediaries because it is as convenient as bank deposits but carries no credit risk.
- Credit providers
⇒ In order to maintain monetary conditions and inflation perspectives unchanged, the central bank refinances banks, which leads to a transfer of credit risk from commercial banks to the central bank.
- Money issuers (fractional reserve system)

Limiting the transfer of credit risk

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Although there is no technical limit to transferring credit risk to the central bank, the prevailing *ordnungspolitische* view favours maintaining the current division of roles.

A digital euro would seek to maintain the healthy equilibrium which has existed for decades between bank deposits and central bank money.

ECB (2023)

Mechanisms for limiting the demand for and supply of CBDC:

- ① Applying a quantity ceiling to CBDC holdings (ECB's choice)
- ② Applying an unattractive interest rate to CBDC

Will CBDC be used as medium of exchange?

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- If CBDC issuance is limited, most people will hold both CBDC and bank deposits.
- Sir Thomas Gresham's law (16th century):
 - Hoard the *good* money without credit risk (CBDC)
 - Spend the *bad* money with credit risk (bank deposits)
- CBDC may not achieve its intended purposes because it will be used as a store of value rather than a medium of exchange.



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Experimental design

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- Monetary exchange economy where a producer and a consumer buy and sell labour and a consumer good to each other.
- Monetary endowment of 50 ECUS (experimental currency units).
- Two types of money
 - Account A: no risk of loss (CBDC).
 - Account B: $\beta = 10\%$ probability of losing $I^B = 50\%$ of the amount (bank deposits).
- Two decisions
 - Decision 1: allocation of monetary endowment between both accounts.
 - Decision 2: simultaneous payment of 10 ECUS to the partner with either account.

Experimental treatments

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- Treatment X1: no quantity ceiling, no unattractive interest rate on account A
 - Account A: $r^A = 0$ and $A^{max} = \infty$
 - Account B: $r^B = 0$ and $B^{max} = \infty$
- Treatment Y1: quantity ceiling of 10 ECUS on account A
 - Account A: $r^A = 0$ and $A^{max} = 10$
 - Account B: $r^B = 0$ and $B^{max} = \infty$
- Treatment Z1: unattractive interest rate of -5% on account A
 - Account A: $r^A = -5\%$ and $A^{max} = \infty$
 - Account B: $r^B = 0$ and $B^{max} = \infty$
- Treatments X2, Y2 and Z2 with $r^B = 5\%$

Timing within a period

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- ① Monetary endowment T
- ② **Decision 1:** allocation of endowment between account A and account B
- ③ Interest rate is calculated
- ④ **Decision 2:** simultaneous payment of 10 to the partner with account A or account B; moreover, participants must indicate how they expect their partner will pay them
- ⑤ Lottery draws with 10% probability the realisation of 50% loss on account B
- ⑥ Interest rate is paid
- ⑦ Calculation of new endowment for the next period

Theoretical predictions: store of value

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Store of value ($S = T$ ECUS - 10 ECUS): no strategic interaction

$$\mathbb{E}(P_S) = (1 + r^A)S_A + (1 + r^B - \beta \cdot I^B)S_B \Rightarrow S_A = S \quad \text{if} \quad r^A - r^B + \beta \cdot I^B > 0$$

	$r^A - r^B + \beta \cdot I^B$	Risk attitude	Store of value	
			S_A	S_B
X1	5%	all types	S	0
Y1	5%	all types	A^{max}	$S - A^{max}$
Z1	0%	Risk neutrality	$[0; S]$	$[0; S]$
		Large loss aversion	S	0
		Rare event underestimation	0	S

Theoretical predictions: medium of exchange

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Medium of exchange ($M = 10$ ECUS): strategic interaction with the partner

$$\mathbb{E}(P_M) = (1 + r^A)M_A + (1 + r^B)M_B - \beta \cdot I^B \cdot M'_B$$

$\mathbb{E}(P_M)$	M'_A	M'_B
M_A	$r^A; r^A$	$r^A - \beta \cdot I^B; r^B$
M_B	$r^B; r^A - \beta \cdot I^B$	$r^B - \beta \cdot I^B; r^B - \beta \cdot I^B$

X1	M'_A	M'_B	Y1	M'_A	M'_B	Z1	M'_A	M'_B
M_A	0*;0*	-0.5*;0*	M_A	0*;0*	-0.5;0	M_A	-0.5;-0.5	-1;0
M_B	0*;-0.5*	-0.5*;-0.5*	M_B	0;-0.5	0*;0*	M_B	0;-1	-0.5*;-0.5*

Theoretical predictions: overview

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Treatment	Risk attitude	Decision 1		Decision 2		$\mathbb{E}(P)$ with $T = 50$
		T_A	T_B	M_A	M_B	
X1	all types	T	0	10	0	100%
Y1	all types	10	T-10	0	10	96%
Z1	Risk neutrality	[0; T-10]	[10; T]	0	10	95%
	Large loss aversion	T-10	10	0	10	95%
	Rare event underestim.	0	T	0	10	95%

Experimental sessions

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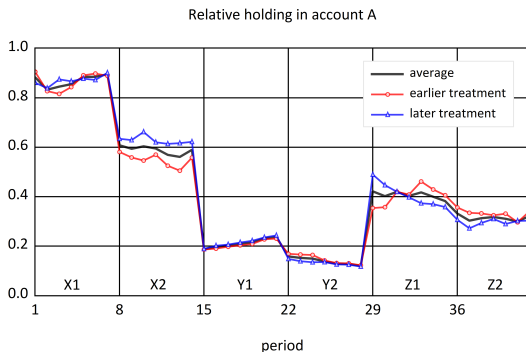
- 120 participants, 6 sessions of 10 pairs of 2 participants
- Each treatment played for 7 periods, 42 periods overall

Period	1-7	8-14	15-21	22-28	29-35	36-42	E(ECUS)	
							Games	Elicitations
Session 1	X1	X2	Y1	Y2	Z1	Z2	272.5	42
Session 2	X1	X2	Y1	Y2	Z1	Z2	272.5	42
Session 3	X1	X2	Y1	Y2	Z1	Z2	272.5	42
Session 4	X2	X1	Z2	Z1	Y2	Y1	272.5	42
Session 5	X2	X1	Z2	Z1	Y2	Y1	272.5	42
Session 6	X2	X1	Z2	Z1	Y2	Y1	272.5	42

- Each session lasted for around 90 minutes
- 12 ECUS = 1 euro; payoffs ranged from 13 to 43 euros; average payoff 29 euros

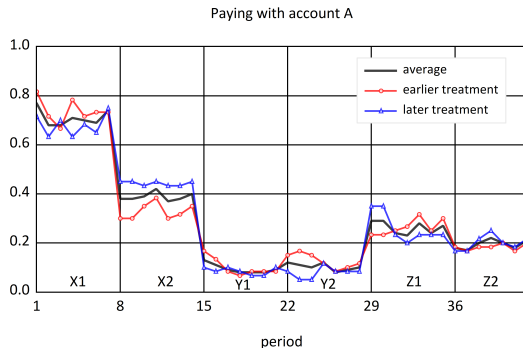
Experimental results: money holdings across treatments

- Large CBDC holdings without ceiling or unattractive interest rate (X1).
- A ceiling (Y) limits CBDC holdings more effectively than an unattractive interest (Z).



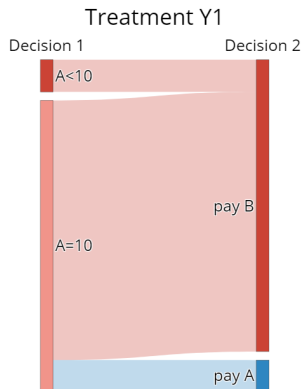
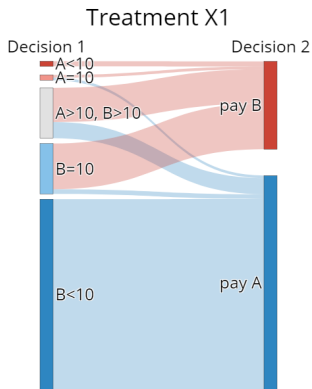
Experimental results: payment decisions across treatments

- CBDC used for payment in 71% of cases without ceiling or unattractive interest (X1).
- CBDC used for payment in 9% of cases with a ceiling (Y1) and 26% of cases with unattractive interest (Z1).



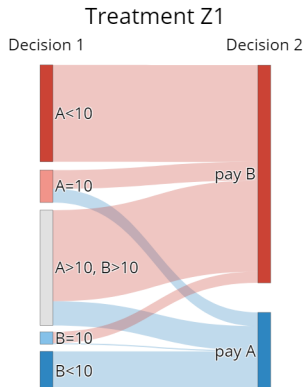
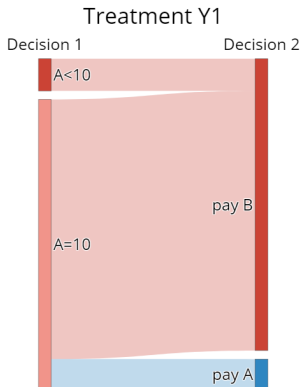
Effect of the ceiling: Gresham's law holds true

- Little effect of the ceiling on the share of participants holding enough CBDC to pay with CBDC.
- Large effect of the ceiling on the share of participants actually paying with CBDC.



Effect of unattractive interest

- Unattractive interest has a larger effect than the ceiling on the share of participants holding enough CBDC to pay with CBDC.
- Unattractive interest has a smaller effect than the ceiling on the share of participants actually paying with CBDC.



Conclusion

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- Some central banks are considering issuing a retail CBDC to promote the diversity and sovereignty of electronic payment systems.
- Gresham's law predicts that CBDC will be hoarded as a store of value rather than used as a medium of exchange.
- A laboratory experiment confirms the prediction of Gresham's law.
 - With no ceiling and no unattractive interest, CBDC is widely held and widely used as a medium of exchange.
 - A ceiling or an unattractive interest significantly impedes the use of CBDC as a medium of exchange.
 - A ceiling is more effective in limiting CBDC issuance than an unattractive interest, but impedes more the use of CBDC as a medium of exchange.
- Promoting the diversity and sovereignty of electronic payment systems would be better achieved with solutions based on commercial bank money rather than CBDC.