Introducing New Forms of Digital Money: Evidence from the laboratory **Notes**

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Experimental evidence shows that introducing interest-bearing digital currencies (CBDCs) can destabilize monetary systems, reduce trade, and harm welfare, highlighting the need for both theory and experimentation in guiding policy design.

The experimental study analyses how central bank digital currencies (CBDCs), especially those that offer interest, affect economic systems. While theoretically promising, these "sophisticated" tokens disrupted stability compared to basic, non-interest bearing tokens. Even when used alongside traditional tokens, they caused issues. This suggests that before adopting such innovations in real-world monetary systems, policymakers should use both theory and experiments to foresee potential unintended consequences.

Introduction

Experimental findings suggest that introducing interest-bearing Central Bank Digital Currencies (CBDCs) can disrupt stable monetary systems, reducing trade efficiency and welfare, highlighting the need for thorough theoretical and experimental analysis before policy implementation. Experimental results show that introducing interest-bearing digital tokens disrupts the spontaneous emergence of a stable monetary system, as positive interest leads to hoarding and reduced trade, while negative interest reduces token acceptability. The study highlights the importance of combining theoretical and experimental approaches in monetary policy design, as seemingly benefical innovations like interest-rate bearing CBDCs may introduce unintended inefficiencies in real economics.

Contribution to the experimental literature

This study expands experimental research on monetary systems by analyzing sophisticated digital tokens, showing that while monetary exchange can support welfare, it is not necessary for efficient outcomes, as alternative nonmonetary strategies also enable economic organization.

Design of the experiment

The experiment models a peer-to-peer trading economy where participants freely decide whether tokens, which have no intrinsic value or external redemption, evolve into a functional currency, making the emergence of money exchange an endogenous outcomes. The experiment models a producer-consumer interaction where producers decide whether to transfer goods, eat them, or sell them for tokens, while consumers with tokens can either spend them to obtain goods or remain idle if they lack tokens.

Token exchange occurs peer-to-peer without intermediaries, and producers must anticipate future trade benefits to give up goods, as cooperative behavior is necessary to maximize overall earnings in the game. The experiment consists of 16 fixed rounds with a probabilistic continuation, ensuring participants experience a consistent environment while preventing predictable end-game behaviors, making the monetary system's evolution more organic. Players are randomly rematched each round to prevent reputation effects, and sessions involve multiple economies running parallel, allowing data collection from diverse interactions while minimizing spillover effects between participants.

The experiment includes different treatments where tokens vary by type (plain or sophisticated) and supply, with sophisticated tokens earning small gains or losses (interest) per round. The baseline Fiat treatment plains token with a fixed supply, while variations include penalties (-1), rewards (1 or 2), increased supply (Fiat2), mixed token types (Mix), and a dynamic replacement of plain tokens with interest-bearing ones in later rounds (Switch).

A theoretical reference

The experiment captures key monetary theory aspects, showing that money facilitates intertemporal trade despite frictions, but monetary exchange is not imposed, allowing alternative nonmonetary solutions to emerge naturally. Payoff expectations depend on individual choices, opponent behavior, and token payoffs, with two reference outcomes: full cooperation (efficient trade) and autarky (full defection), where only producers consume.

Autarky payoffs for initial producers and consumers:

$$\widehat{v_p} = \frac{d + \beta(d - l)}{1 - \beta^2}$$

$$\widehat{v_c} = \frac{u + d - l + \beta(d + u)}{1 - \beta^2}$$

- $\widehat{v_p}$: Producer's Autarky Payoff
    - d: Immediate benefit (points) from consuming the good.
    - l: Opportunity cost of production.
    - β: Discount factor, representing the probability of continuation after each round.
    - β^2: Accounts for future rounds' impact on expected payoffs.
- $\widehat{v_c}$: Consumer's Autarky Payoff
    - u: Flow payoff from holding a token (interest or penalty).
    - d: Immediate consumption benefit for the consumer.
    - l: Cost incurred in the exchange process.
    - $\beta(d + u)$: The discounted effect of future payoffs.
    - $1 - \beta^2$: The denominator normalizes expected values considering infinite rounds.

These equations describe how players' expected payoffs evolve in an environment where token trade is not enforced, and defection (D) is the dominant strategy in the autarky equilibrium.

A nonmonetary equilibrium can sustain efficient trade through a trigger strategy, where producers cooperate (C) unless a defection (D) occurs, which leads to permanent autarky as punishment, ensuring incentive compatibility. Efficient allocation is achieved when the continuation probability β is high enough ($\beta \geq \beta^*$), but multiple equilibria exist, including autarky, meaning tokens are not strictly necessary for efficient outcomes.

Efficient Payoffs for Producers and Consumers

$$v_p \coloneqq \frac{a + \beta g}{1 - \beta^2}$$

$$v_c \coloneqq \frac{u + g + \beta(a + u)}{1 - \beta^2}$$

Continuation Probability for Efficient Play:

$$\beta^* \coloneqq \frac{d - a}{g - d + l}$$

- v_p (Producer's Efficient Payoff)
    - a: Immediate benefit from cooperation.
    - g: Future gains from cooperation.
    - β: Discount factor representing continuation probability.
    - $1 - \beta^2$: Normalization for repeated rounds.
- v_c (Consumer's Efficient Payoff)
    - u: Flow payoff from holding a token.
    - g: Immediate gain from cooperation.
    - $\beta(a + u)$: Future expected gains from sustained cooperation.
- β^* (Minimum required continuation probability)
    - $d - a$: Net gain from defecting instead of cooperating.
    - $g - d + l$: Total potential benefit from cooperation.

- If $\beta \geq \beta^*$, cooperating is self-enforcing, ensuring efficient trade.

This framework shows that monetary exchange is not strictly necessary – efficient allocation can emerge through cooperative strategies and long-term incentives.

In monetary equilibrium, tokens function as currency, enabling quid-pro-quo trade between producers and consumers, supporting efficient reallocation of goods while redistributing the token's flow payoff u. The existence of monetary equilibrium depends on the producer's incentive to delay consumption in favor of a future benefit, with the threshold discount factor $\beta^*(u)$ decreasing as u increases, making monetary equilibrium more likely. Hypotheses suggest that monetary trade should be more frequent when tokens yield benefits, not decline when benefit-yielding tokens replace plain tokens, and hoarding should not occur, ensuring efficient token circulation.

Payoffs in Monetary Equilibrium for Producers and Consumers:

$$v_p(0) := \frac{a + \beta(u+g)}{1-\beta^2}$$

$$v_c(1) := \frac{u + g + \beta a}{1-\beta^2}$$

Threshold Discount Factor for Monetary Equilibrium:

$$\beta^*(u) = \frac{d-a}{u+g-d+l}$$

- $v_p(0)$ (Producer's Payoff in Monetary Equilibrium)
    - a: Immediate consumption benefit in equilibrium.
    - β: Discount factor, representing the probability of future rounds.
    - u: Flow payoff from holding a token (interest or penalty).
    - g: Future gains from cooperation.
    - $1-\beta^2$: Normalization for an infinite time horizon.
- $v_c(1)$ (Consumer's Payoff in Monetary Equilibrium)
    - u: Token's flow payoff (interest or penalty).
    - g: Immediate consumption gain.
    - βa: Future benefits from cooperation.
- $\beta^*(\boldsymbol{u})$ (Threshold Discount Factor for Monetary Equilibrium)
    - $d-a$: Difference between defection and cooperation benefits.
    - $u+g-d+l$: Net expected benefit from monetary trade.
    - A lower $\beta^*(u)$ means that monetary equilibrium is more easily sustained when u is positive.

These results highlight how monetary trade and nonmonetary arrangements can coexist, with efficiency depending on incentive structures and discount factors.

Results

There is a strong positive correlation ($\rho = 0.754$) between the frequency of monetary trade and realized efficiency, indicating that economies where monetary exchange occurs more frequently achieve higher efficiency. Economies using only plain tokens perform better than those with sophisticated tokens, with 56% of plain-tokens economies reaching at least 50% efficiency, compared to only 14% of sophisticated-token economies. The result suggest that not all tokens equally support efficient trade. Plain tokens facilitate more frequently monetary transactions, while sophisticated tokens (especially interest-bearing ones) slow down or prevent the development of a stable monetary system.

Participants in fiat (plain token) economies learned to coordinate on efficient play over time, increasingly relying on monetary trade rather than gift-giving, leading to higher cooperation levels. Despite this improvement, full cooperation was not achieved due to token illiquidity and acceptability issues, as some participants consistently refused to trade, preventing tokens from circulating optimally. The result show that monetary trade improved cooperation, but economies with sophisticated tokens struggled due to acceptibility issues, reinforcing that plain tokens were more effective in fostering trade and coordination.

Replacing plain tokens with sophisticated tokens reduced cooperation and prevented participants from effectively coordinating on efficient trade, as shown by significantly lower monetary trade frequencies. A small penalty for holding tokens made them less acceptable, discouraging trade, while a small benefit encouraged hoarding rather than spending, both of which reduced token circulation compared to plain tokens. The results indicate that sophisticated tokens disrupted the spontaneous emergence of a monetary system, as they altered incentives in a way that discouraged efficient trade, leading to lower realized efficiency.

The introduction of sophisticated tokens led to hoarding, reducing the circulation of both plain and benefit-yielding tokens, which in turn prevented the emergence of an efficient monetary trade system. In mixed-token economies (mix treatment), trade did not improve despite the availability of plain tokens, as players tended to hoard sophisticated tokens while selectively refusing to trade plain tokens, further exacerbating coordination failures. The presence of sophisticated tokens increased the frequency of failed trades, as mismatches between offered and demanded token types resulted in non-cooperation, leading to significantly lower monetary trade levels compared to economies with only plain tokens. The result show that adding sophisticated tokens to an economy hindered monetary trade by introducing unnecessary friction in the exchange process, leading to lower cooperation, and efficiency despite the theoretical benefits of interest-bearing tokens.

The switch treatment, which replaced plain tokens with benefit-yielding tokens after Supergame 2, led to a permanent decline in monetary trade and cooperation, indicating that the transition to sophisticated tokens disrupted the monetary system. The result show that while initial coordination with plain tokens facilitated some level of monetary trade, the introduction of benefit-yielding tokens reduced token circulation due to hoarding, ultimately stunting the development of an efficient exchange system.

Discussion

Monetary trade enhances efficiency: The study demonstrates a strong positive association between monetary trade and realized efficiency. When a monetary system does not emerge or functions poorly, efficiency declines because participants cannot coordinate on high-payoff equilibria.

Plain tokens support cooperation, while sophisticated tokens hinder it: Participants in economies with plain tokens learned to optimize resource allocation via monetary trade, while interest-bearing tokens failed to develop a functioning monetary system, reducing cooperation and efficiency.

Policy implications for digital currencies: The study suggests that introducing a new currency instrument, such as Central Bank Digital Currencies (CBDCs), without appropriate mechanisms (e.g., legal tender status) could lead to uncertainty, mistrust, or miscoordination. An effeftive currency should be plain, free of additional valuation complexities, and focused on its role as a means of payment.