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Experimenting with Digital Currency*

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Abstract

Sovereign digital currencies are about to be launched in several countries. A key feature of this intangible counterpart of cash is its traceability. Using a microfounded monetary model, we show that traceability can be exploited to incentivize liquidity transfers among traders, thus stimulating production and trade. We empirically test the theoretical prediction through a controlled laboratory experiment. We find that sovereign digital currency stimulates production and trade, provided that the authorities actively help promote its acceptability.

Keywords: digital currency, cash, monetary policy, laboratory experiment
JEL codes: E40, C90

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1 Introduction

Sovereign digital currencies, defined as widely available liabilities of the central bank that would serve as intangible counterparts to cash, are about to be launched in several countries.[1] A key intrinsic difference between sovereign digital currency and cash is its *traceability*.[2] In this paper, we explore the consequences of conceiving sovereign digital currency – henceforth simply *digital currency*– as traceable cash.

Specifically, within a microfounded monetary model, we show that the traceability of digital currency can be exploited by monetary authorities to incentivize liquidity transfers that, in turn, stimulate trade and output. We test the theoretical prediction in a controlled laboratory experiment, finding that output in the digital currency economy is indeed greater than in the corresponding cash economy due to the additional liquidity transfers that become available with digital currency, provided the authorities actively support its acceptability. As empirical evaluations of digital currency remain scarce, largely due to limited data availability given the early stage of implementation, our experimental approach helps address this gap by employing a laboratory experiment grounded in monetary theory to generate evidence on how features of digital currency can be leveraged to affect macroeconomic outcomes, by opening the door to the design of new, unconventional monetary policies.

Since the theory, which is based on the monetary matching model of Kiyotaki and Wright (1989, 1993), admits multiple equilibria, with autarky along with the monetary equilibrium, we must take care in designing the experiment, as the coordination of traders' expectations could result in the absence of trade invalidating the entire exercise. We employ a two-by-two between-subjects design with treatment variables consisting of currency type, cash vs. digital, and the presence of a suggestion. The purpose of the first variable is to test whether digital currency leads to better allocations, while the purpose of the second variable is to facilitate traders' coordination on monetary equilibria.

[1] For example, see Di Iorio *et al.* (2024) for a survey indicating that central banks around the world are taking into account different design features and proceeding at different speeds. The ECB has a website about the digital euro (allegedly to be launched in 2026): `https://www.ecb.europa.eu/euro/digital_euro`. Some countries have already launched or piloted digital currency, while others are in the process of developing it. For an up-to-date overview of the status of sovereign digital currencies across countries, see `https://cbdctracker.org/`.

[2] In Amendola *et al.* (2025a,b) digital currency is conceived as a technology that traces monetary flows.

In the experiment, participants are randomly paired to trade indivisible items and tokens. At first, half of the participants in the economy are assigned a token that has no intrinsic value. In each period, there are two types of bilateral matches: those in which a potential consumer with a token meets a potential producer without a token, and those in which a potential consumer without a token meets a potential producer with a token. Within a match, the potential producer may or may not produce something for the potential consumer. When the potential consumer holds the token, she can transfer it to the potential producer in exchange for production; when the potential producer holds the token, she may transfer it to the potential consumer so that she can use it to pay for production. Subjects engage in negotiations to determine the terms of trade.

In the cash economy, the token accounts of the participants cannot be monitored, and the participants do not face any consequences for not transferring the token, keeping it idle. In the digital currency economy, token accounts of participants are monitored and there can be consequences should they choose to keep their token idle. In particular, if participants hold a token at the beginning of a period and do not transfer it during the period, the token is confiscated from their account and reassigned at random to someone who does not hold any token in the economy, thus keeping the supply of currency constant. In other words, the treatment mimics a situation in which the authority imposes a nominal tax on idle accounts. The provision of incentives to transfer liquidity by threatening to tax idle balances simplifies the experimental design. The policy is equivalent to charging negative interest on idle balances.[3] In equilibrium, no tax is actually levied. Off-equilibrium, some tokens remain idle and taxes are levied. This reduces the value of the token and may lead to a breakdown of monetary trade, affecting the selection of equilibrium. In the treatments with suggestion, the participants receive a partial suggestion about the strategy to follow. The suggestion is partial because we only implement it in the meetings in which the potential consumer has the token and does not specify the amount to be produced. Specifically, subjects in these meetings are told that they may want to consider a strategy by which the consumer proposes to transfer the token and the producer accepts to produce in exchange for the token. We interpret this suggestion

[3]Negative interest rate policies are discussed in Krugman (1998), Buiter (2009) and Rogoff (2016). Alternatively, one could endow digital currency with an expiration date, as discussed in Buiter (2009) and Kahn *et al.* (2024).

as a coordination device, similar to real-world communications from authorities that presume that currency is accepted as a means of exchange. Importantly, the suggestion is *not* implemented in the meetings where the producer holds the token, that is, the meetings in which we expect to see a difference between digital currency and cash.

Based on our theoretical model, in the cash economy, we expect production to occur only when the potential consumer holds the token; in the digital currency economy with taxation of idle tokens, we expect production to occur also when the potential producer holds the token because the threat of taxation incentivizes the transfer of tokens. This implies that a larger share of the available gains from trade is realized in the digital currency economy than in the cash economy. We expect more trade to occur with the suggestion than without it, as it facilitates the traders' coordination on the use of currency.

In the absence of suggestion, we find that overall production does not increase significantly in the digital currency economy relative to the cash economy. To be sure, production increases in meetings in which the potential producer has the token in the digital currency economy. However, this increase is offset by an equal decrease in production when the potential consumer holds the token. This is due to the reluctance of producers to produce for the token when taxes may be levied on it. Thus, without suggestion, the policy aimed at stimulating trade is ineffective. Instead, with the suggestion, overall production increases substantially in the digital currency economy compared to the cash economy. In particular, production increases significantly when potential producers hold the token and remains roughly the same as with cash when the potential consumer holds the token. Thus, with the suggestion, the policy aimed at stimulating trade is successful.

Our results indicate that digital currency has the potential to achieve better allocations than cash. However, for this to happen, the monetary authority should help the economy coordinate toward an equilibrium in which digital currency is accepted.

The paper proceeds as follows. Section 2 discusses the relevant literature. Section 3 presents the model with its theoretical predictions. Section 4 describes the experimental setting. Section 5 discusses the results. Section 6 concludes. Appendix A contains the experimental instructions; in Appendix B there are further results and robustness checks.

2 Literature

The growing interest in sovereign digital currencies has led to a surge in theoretical work exploring their design, implementation, and implications (see Ahnert *et al.* (2024) for a review). Microfounded monetary models are particularly well suited to study digital currencies, as they explicitly incorporate the role of money in facilitating exchange. Existing research has focused primarily on macroeconomic and financial considerations, such as the impact of digital currencies on monetary policy transmission, financial stability, and bank disintermediation or issues of privacy, security, and access (e.g. Andolfatto (2021), Chiu *et al.* (2023), Keister and Sanches (2023), Agur *et al.* (2022) or Garratt and van Oordt (2021)).

The traceability of digital currency has been examined theoretically in Amendola *et al.* (2025a,b). In a Lagos and Wright (2005) framework with endogenous participation decisions, Amendola *et al.* (2025a) show that paying higher interest on active than idle balances, which is feasible with digital currency due to the traceability of digital balances, helps foster participation, achieving efficiency along both intensive and extensive margins, an outcome that cannot be obtained with either cash or digital currency paying uniform interest on all balances. In this paper, as in Amendola *et al.* (2025b), we consider an environment based on Kiyotaki and Wright (1989, 1993), with indivisible goods and tokens that simplifies the experimental implementation.

In a random matching model à la Kiyotaki and Wright (1989, 1993) with indivisible cash and individual holdings bounded at 2 units, Deviatov and Wallace (2001) have shown that a probabilistic version of lump-sum cash creation can improve production and trade by changing the distribution of money holdings. In our setting, due to its traceability, the digital currency allows redistribution of the existing currency without the need to create additional currency. Importantly, our off-path tax on idle balances should not be confused with the implementation of inflationary policies within first-generation monetary models, where fiat money is confiscated indiscriminately with some probability (e.g. Li (1995), Babutsidze *et al.* (2025)). A key feature of our framework is currency traceability, allowing currency confiscation to target idle balances in the digital accounts. In contrast to indiscriminate confiscation, the policy we propose is optimal. A related feature of digital currency is its programmability that allows the automatic execution of payments through smart contracts, with potential efficiency gains, as argued by Kahn and van Oordt (2022). Programmability is also discussed by Chiu and Monnet (2025).

Incentives to share liquidity are provided with a policy that mimics negative interest on idle balances. The debate on negative nominal interest rates dates back to Krugman (1998), in connection with the zero lower bound. Buiter (2009) pointed out that institutional constraints may explain the reluctance to adopt negative rates. Rogoff (2016) suggested that reducing cash dependence could expand the capacity of central banks to employ negative rates.

A substantial body of research integrates monetary theory and experimental economics to investigate core questions in monetary economics. Some studies examine foundational questions related to the selection of equilibria and the essentiality of money, while others explore the effects of different monetary policies or the coexistence of multiple (domestic or international) currencies (e.g. Bigoni *et al.* (2019) Bigoni *et al.* (2020), Camera *et al.* (2013), Marimon and Sunder (1993), Brown (1996), Duffy and Ochs (1999), Camera and Casari (2014), Duffy and Puzzello (2014b), Duffy and Puzzello (2014a), Jiang and Zhang (2018), Rietz (2019), Ding and Puzzello (2020), Duffy and Puzzello (2022), Davis *et al.* (2022), Arrieta Vidal *et al.* (2022), Jiang *et al.* (2023), Jiang *et al.* (2024), Cardozo *et al.* (2024), Babutsidze *et al.* (2025), and Arifovic *et al.* (2025)).

Empirical evidence on digital currency remains limited, largely due to the scarcity of available data. However, some studies use data from existing payment surveys to indirectly estimate the demand for digital currency and better understand its drivers (e.g. Nocciola and Zamora-Perez (2025), Li (2022), Huynh *et al.* (2024)). Choi *et al.* (2025a) and Choi *et al.* (2025b) design randomized online survey experiments to examine how attributes, including privacy protection and the form of issuance, affect the adoption of digital currency. Our experimental approach complements these empirical contributions.

The only experimental paper on digital currency that we are aware of is Camera (2024), which examines the question whether digital currency that pays a uniform positive or negative real interest can affect trade and economic efficiency. Theory predicts that trade should be at least as frequent when digital currency yields a benefit, and not more frequent when it carries a cost. Contrary to theory, in the lab, Camera (2024) finds that *uniform* interest leads to worse results, since subjects tend to hoard or reject digital currency. Instead, we find that digital currency can stimulate production if active and idle balances are treated *differently*.

3 Theory

Consider a monetary search and matching model à la Kiyotaki and Wright (1989, 1993) with indivisible fiat money and indivisible goods. The time horizon is discrete and infinite. The economy is populated by a unit continuum of agents. Consumption of one unit of goods gives utility u and production of one unit of goods costs c, with $u > c > 0$. Agents can produce and consume at most two units of goods.[4] Agents live forever and discount the future at a rate $\beta < 1$. Meetings between traders are bilateral and random. Since there is a continuum of traders, meeting twice the same trading partner is a zero-probability event. The matching technology is such that the probability of meeting a past trading partner of a current trading partner for any trader is also nil.[5]

3.1 Media of exchange

We consider two alternative economies, with different media of exchange, cash or digital currency. Both cash and digital currency are durable, intrinsically worthless objects, that is, they are fiat money. The only difference between the two monetary instruments is that digital currency flows can be monitored by the monetary authority, whereas cash flows cannot be monitored. As in Kiyotaki and Wright (1989, 1993), money comes in indivisible units. For simplicity, we assume that traders can hold at most one unit of money. Half of the population of traders starts with one unit of money, while the rest initially hold nothing. An agent with money always meets an agent without money, and a random draw determines the producer and the consumer in the meeting.[6] In either economy, there will be two rounds of exchange in each meeting between pairs of traders. In the first round, only money can be exchanged;

[4]The restriction to quantities in the set $\{0, 1, 2\}$ simplifies the implementation of the experiment. For the model with lotteries and divisible quantities, see Amendola *et al.* (2025b).

[5]As a consequence, trade based on reputation or contagion à la Araujo (2004) cannot be sustained. Therefore, we concentrate on *quid pro quo* trade with media of exchange. In the experiment, the population will be finite, hence, potentially, there may be some reputation-based or contagion-based trade. The equilibria with trade based on media of exchange identified in the model with a continuum population survive in the corresponding model with a finite population. In addition, Duffy and Puzzello (2014b) find that the subjects in the laboratory cannot coordinate on the social norms of exchange based on reputation.

[6]Our random matching technology is "frictionless" in the sense that every meeting generates potential gains from trade (see Matsui and Shimizu (2005) for a related matching technology within marketplaces). This assumption is without loss of generality, as it does not affect the main results of the model.

in the second round, goods can also be exchanged. Next, we describe the best implementable allocation, first in the cash economy and then in the digital currency economy.

3.2 Cash

Consider first a trading system based on cash whose flows and holdings cannot be traced by the authorities; hence, cash transfers between traders cannot be incentivized. There are only two types of meetings: those in which only the buyer has cash and those in which only the seller has cash. In the former type of meetings, the traders move on directly to the second round, in which cash is transferred from buyers to sellers against two units of the good. In the latter type of meetings, nothing happens. Production of two units of goods occurs in half of the meetings. Clearly, this is the best feasible allocation with cash.

We compute the expected value for traders with and without cash, assuming the participation of traders in the scheme just described. The expected value of traders who currently hold one unit of cash is

$$V_1 = \frac{1}{2}(2u + \beta V_0) + \frac{1}{2}\beta V_1,$$

as traders with cash may be, with equal probability, either buyers of two units of the good paying with cash or sellers, and thus inactive. In turn, the expected value of traders without cash is

$$V_0 = \frac{1}{2}(-2c + \beta V_1) + \frac{1}{2}\beta V_0,$$

as traders without cash may be, with equal probability, producers of two units of the good acquiring cash or inactive. The difference in the expected values for traders with and without cash reflects the value of holding cash, that is,

$$V \equiv V_1 - V_0 = u + c. \tag{1}$$

The value of cash (1) reflects the expected benefit and covers the expected cost of trading two units of goods on average half of the time.

3.2.1 Implementability

Since participation in the scheme at any time is voluntary, we need to check incentive-compatibility. First, buyers should be willing to transfer cash for two units of the good, that is, $2u \geq \beta V$, which, by (1), is always satisfied since $u > c$ and $\beta < 1$. Second, sellers without cash should be willing to produce two units of the good to obtain cash, that is, $2c \leq \beta V$, which, inserting (1), is equivalent to

$$\beta \geq \frac{2c}{u+c} \equiv \underline{\beta}, \tag{2}$$

where $\underline{\beta} < 1$ since $u > c$. If $\beta \geq \underline{\beta}$, the best allocation that can be obtained with cash is implementable. Since this allocation is incentive compatible, it can be decentralized, for instance, assuming that cash holders make take-it-or-leave-it offers to sellers, as buyers would ask for two units of goods instead of one and sellers would accept under the condition (2). In the experiment, we adopt a bargaining protocol that mimics these offers.

3.3 Digital currency

Consider now the digital currency economy. Traders have exactly one digital account open from the beginning with the monetary authority and cannot open new accounts. There are only two types of meetings: those in which only the buyer has digital currency and those in which only the seller has currency. In the former type of meetings, traders move on directly to the second round, in which digital currency is transferred from buyers to sellers against two units of the good; in the latter type of meetings, in the first round, digital currency is transferred from sellers to buyers, in the second round, currency is returned from buyers to sellers against one unit of the good.[7] Trade occurs in all meetings, but with higher production in meetings in which buyers have currency than in those in which sellers have currency. This is the

[7]For simplicity, all the action is condensed within a match. Although transferring a token to receive it back in exchange of production may seem unrealistic, this may be thought of as a reduced form of a more complex scenario in which producers transfer currency they do not need to consumers in need, who use it to buy two units of goods transferring one to the original owner as repayment. The original owner can then receive currency from another buyer in exchange for two units while paying the cost for one unit only. The allocation in this scenario is identical to that in our theory, but requires matching traders outside the current trading match

best feasible allocation with digital currency.[8] The authorities observe the balances and flows in and out of the accounts of all the traders but cannot observe the traders' roles or the amount produced. The authorities remove any idle digital currency in accounts during any period.[9] The idea is that, when currency is misallocated, liquidity transfers among traders are incentivized by the threat of taxation of idle balances.

We now consider the expected value for traders with and without digital currency, assuming the participation of traders. The expected value of traders who currently hold one unit of digital currency is the same as in the corresponding cash economy, reduced by the expected cost of production of one unit of goods for sellers with currency $c/2$, since sellers with currency, instead of being inactive, are now incentivized to transfer liquidity and produce for buyers; the expected value of traders without digital currency is the same as in the corresponding cash economy augmented by the expected benefit of consumption of one unit of goods for buyers without currency $u/2$, since buyers without currency, instead of being inactive, now receive a liquidity transfer and can consume.[10] Compared to the cash economy, there is an additional trading option between producers with currency and consumers without currency, due to the liquidity transfers that become feasible with digital technology. Since traders can sometimes acquire consumption without initially holding currency due to liquidity transfers and sometimes need to produce to receive the token back when holding currency, the incentive to acquire currency is reduced relative to the cash-based system. Consequently, the value of digital currency, which is given by the difference between the expected values of traders with and without digital currency, is half the value of cash, being reduced by $(u + c)/2$.

[8] If the same quantities were traded at both meetings, the allocation would not be implementable, since the value of currency would be nil. If nothing is produced in the meetings in which producers have currency, the scheme is equivalent to cash. As a consequence, without lotteries on money and goods, the only relevant case has two units produced in meetings in which the consumer has currency and one unit produced in meetings in which the producer has currency.

[9] In the mechanism design version of this model analyzed by Amendola *et al.* (2025b), harsher punishments are considered, such as freezing accounts. This would make it easier to incentivize liquidity transfers relative to taxation. In this paper, we consider a scheme that is more amenable to implementation in the laboratory.

[10] We have written the expected values anticipating that production and consumption of two units of goods in the meetings with liquidity transfers would not be implementable, since the difference between expected values, reflecting the value of currency would be nil.

3.3.1 Implementability

Next, we check incentive-compatibility. Buyers without currency have the incentive to transfer currency for one unit of consumption since $u > 0$. Since buyers have the incentive to transfer currency for two units of consumption in the cash economy and digital currency is less valuable than cash, *a fortiori*, buyers have such an incentive in the digital economy. Since production of two units of goods is more costly than one unit, sellers with currency have the incentive to produce whenever sellers without currency have such an incentive. Finally, since the value of digital currency is half the value of cash, the lower bound on discounting to ensure the incentive to produce two units in the digital system must be twice the corresponding lower-bound on discounting in the cash system, $2\underline{\beta}$. By the definition of $\underline{\beta}$ given in (2), to guarantee that $2\underline{\beta} < 1$, we need to assume that the gains from trade are sufficiently large, $u > 3c$. Under this assumption, if $\beta \geq 2\underline{\beta}$, the allocation with digital currency is implementable and, hence, can be decentralized, for instance, assuming that currency holders make take-it-or-leave-it offers to their counterparts, as they would ask for two units as buyers and offer one unit as sellers, and the counterparts would accept under the assumptions. The protocol in the experiments mimics these offers.

3.4 Theoretical results

Since the discounting threshold for the digital system is twice that for cash, the implementability of the former implies that of the latter. In terms of output, an additional unit of production occurs in half of the meetings with digital currency relative to cash because of the liquidity transfers. In the cash economy, half of the available gains from trade are realized every period, while in the digital currency economy, an additional fourth is realized every period. Hence, the welfare is 50% higher with digital currency than with cash. The next proposition summarizes the theoretical results.

Proposition 1 *Assume $u > 3c$ and $\beta \geq 2\underline{\beta}$. Then: a. the cash-based and digital-based allocations are implementable and decentralizable through take-it-or-leave-it offers by currency holders. b. Output and welfare are higher with digital currency than with cash, due to liquidity transfers from producers with currency to consumers without currency that become feasible with digital currency.*

4 Experiment

We designed the experiment to test the theoretical predictions summarized in Proposition 1. We set the parameters $u = 7$, $c = 1$, and $\beta = 0.9 > 0.5 = 2\underline{\beta}$ to satisfy the assumptions of the proposition. In addition to the main task, subjects also participated in additional tasks and answered two short surveys to control for factors that have been shown to matter in other experiments or could help explain departures from theoretical predictions.

4.1 Main task: Monetary economy

The participants play a dynamic game designed to implement the model presented in Section 3. They participate in multiple dynamic games. We refer to each repetition of the dynamic game as a *sequence* and to a single repetition of the stage game within the sequence as a *period*. Participants start each sequence with an endowment of 5 points. At the beginning of each sequence, half of the participants in the economy are randomly endowed with one token. At the beginning of each period, each participant holding a token is randomly paired with a participant without a token; then, the two participants are randomly assigned the role of producer and consumer within the pair. This procedure generates two types of meetings: in half of the meetings, a consumer with a token is matched with a producer without a token, while in the other half of the meetings, a producer with a token is matched with a consumer without a token. In the former type of meetings, which we refer to as Consumer meetings, theory predicts that production should occur both with digital currency and with cash; in the latter type of meetings, which we refer to as Producer meetings, theory predicts that production should occur with digital currency but not with cash.

Stage game. The payoffs in every period are determined by how many units are produced in the pair (0, 1 or 2), as reported in Table 1. Each unit produced costs 1 point to the producer ($c = 1$) and generates a utility of 7 points to the consumer ($u = 7$), implying positive gains from trade. The outcome of each period in each pair consists of the production level and the allocation of the token to one of them. Table 1 shows the benefits and costs of production as shown in the instructions.

In the meetings in which the consumer has the token, there are three possible outcomes: i) the consumer keeps the token and the producer produces 0; ii) the

Table 1: Benefits and Costs (in Points) of production

Quantity produced	Consumer's Benefit	Producer's Cost
0	0	0
1	7	1
2	14	2

Notes: The Table reports the stage payoffs (gains for the Consumer, losses for the Producer) for each quantity produced in a match.

consumer transfers the token and the producer produces 1 unit; or iii) the consumer transfers the token and the producer produces 2 units. In the meetings in which the producer has the token, the consumer cannot directly transfer the token in exchange for production. However, the producer can transfer the token to the consumer and request it back in exchange for production. In this case, there are three possible outcomes: i) the producer keeps the token and produces 0; ii) the producer transfers the token to the consumer and receives it back in exchange for 1 unit; or iii) the producer transfers the token to the consumer and receives it back in exchange for 2 units.

The model presented in Section 3 compares the arrangements that can be implemented with cash and digital currency without a specific protocol to determine the terms of trade, taking only the outcomes into account for incentive feasibility. In principle, the terms of trade could be determined in different ways, through a take-it-or-leave-it offer by the player who holds the token or a simultaneous-move coordination game between them. Since we are not interested in situations in which the pair would agree to produce but fail to coordinate on the number of units to produce, we set up a bargaining procedure that minimizes coordination failures. As mentioned in Sections 3.2.1 and 3.3.1, the best feasible allocations can be decentralized through a bargaining protocol that mimics a take-it-or-leave-it offer by the agent holding the token.

Specifically, the terms of trade are determined through a multistage bargaining protocol, where the participant who holds the token at the beginning of the period always acts as the first mover and the other participant acts as the second mover. In the first round of negotiation, the first mover proposes one of the possible outcomes described above. The second mover can: (*i*) accept the proposal, in which case the offer is implemented and the negotiation ends, (*ii*) reject the proposal, in which case nothing happens and the negotiation ends, (*iii*) make a different proposal. We allowed more than one round of proposals, up to at most three rounds, to avoid high rejection rates merely due to coordination failures (see also Duffy and Puzzello (2014b)). However, note that the final proposal is always made by the participant holding the token, preserving a take-it-or-leave-it structure.[11]

At the end of each period, participants receive detailed information about the result of their interaction in the period: how many units were produced, the number of points earned in the period, and the balance of their token account at the beginning and at the end of the period. They also see the total points they collected over periods and a table with their results in all the previous periods of the sequence.

Dynamic game. We implement the infinite-horizon dynamic game with discount factor β described in Section 3 as a dynamic game with indefinite duration where the probability of continuation is equal to β after every period (Roth and Murnighan, 1978). In particular, at the end of each period, a new period begins with probability $\beta = 0.9$: a random number in the set $\{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$ is drawn uniformly and the sequence ends only if the number is 10. To ensure comparability across treatments, the draws are pseudo-randomized. A script generates streaks of randomly drawn integers between 1 and 10. We generate as many streaks as the number of sessions in one treatment and then assign each predetermined random streak to exactly one session in each treatment. In this way, we ensure that within a treatment each session differs in the length of its sequences, but across treatments, the distribution of sequence lengths is comparable.

We implement the indefinite horizon using a block random termination procedure (Fréchette and Yuksel, 2017; Jiang *et al.*, 2024). Participants play a first block of 10 periods and are informed of the termination period only at the end of the block. So, at the end of period 10 of a sequence, they learn the numbers extracted in periods 1 to 10. If the sequence has already ended within the block, any decisions made after the termination period are ignored, and the points earned in these periods do not count for payment. If the sequence continues beyond period 10, from period 11 onward, participants are notified after each period whether the sequence proceeds or not. When a sequence ends, the subjects are told that a new indefinite sequence may begin depending on the available time. The points earned in all sequences were

[11] Figure B.1 in Appendix B shows the distribution of actual bargaining rounds exploited by the participants in the experiment.

converted into dollars at the exchange rate of 1 *point* = USD 0.25.

4.2 Treatments

The experiment follows a 2×2 between-subjects design. The first treatment variable is the type of currency available in the economy. That is, whether the token is cash (C) or digital currency (D). In treatments C, real trades are unobservable, and currency flows are not traceable. Within a sequence, the token always stays in the account of the participants who hold it at the end of the previous period. In treatments D, real trades are unobservable, but currency flows are traceable. Within a sequence, the token stays in the account of the participants that hold it at the end of the previous period if the token changed accounts at least once during the period. If the token remained idle in the account during the whole period, it is taken away from the account and reassigned at random to one participant that does not hold any token. Therefore, consumers who hold the token and do not transfer it in exchange for production, as well as producers who hold the token and do not transfer it, are subject to a nominal tax. Since the token has no intrinsic value, the tax is neutral unless the token gains value because it is accepted in trades. In monetary equilibrium, no tax is actually levied because the accounts are never idle.

The second treatment variable is the presence of a suggestion as to whether the token should be accepted as a means of exchange at the meetings where the consumer holds the token. Although we focus on the monetary equilibria decentralizing the allocations described in Section 3, other equilibria exist in the game (including the autarkic equilibrium). The purpose of the suggestion is to facilitate coordination on the monetary equilibrium where cash or digital currency has a positive value. It is inspired by Myerson's mediator as a coordination device (Myerson, 1986), the classical interpretation of equilibrium as a credible assignment of strategies, and has already been applied in the laboratory to coordination games (Van Huyck *et al.*, 1992; Duffy and Feltovich, 2010) and to monetary economies (Jiang *et al.*, 2024). The suggestion, as shown to the participants, reads as follows: *The Consumer and Producer may consider making the following choices: i) The Consumer transfers the token to the Producer; ii) The Producer produces in exchange for the token. This is simply a suggestion. Feel free to follow it or not.*

The suggestion appears only in meetings where the consumer holds the token.

No suggestion is provided when the Producer holds the token. To further reduce interference with subjects' decision making, it does not specify the amount to be produced.

Treatments without suggestion are denoted as $C0$,$D0$ and with suggestion as $C1$,$D1$. Guided by the theoretical predictions, we test the following hypothesis.

Hypothesis 1 *a. In Producer meetings, production is higher with digital currency than with cash (*$D0$ *and* $D1$ *vs* $C0$ *and* $C1$*); b. The difference in production between digital currency and cash is larger in treatments with suggestion (*$D1$ *vs.* $C1$*) than in treatments without suggestion (*$D0$ *vs* $C0$*).*

4.3 Other tasks

We collect data from two other tasks: the Cognitive Reflection Test (CRT) (Frederick, 2005) and Social Value Orientation (SVO) (Murphy *et al.*, 2011). We also collect a non-incentivized measure of risk attitudes. We used the validated question (1-10 scale) from the SOEP German panel (Dohmen *et al.*, 2011).

The CRT measures an individual's ability to override an initial, intuitive response with reflective, deliberate reasoning. The CRT consists of three questions. Each item has an intuitive but incorrect answer and a correct, non-intuitive answer. The task is incentivized: participants earn USD 1 for each correct answer.[12] It is meant to measure a specific facet of cognition, reflectivity. However, its score is known to correlate more broadly with different measures of cognitive ability (Hertzog *et al.*, 2018; Toplak *et al.*, 2011; Willadsen *et al.*, 2024). Strategic reasoning is a complex task that requires deep thinking, and this is even more the case in our dynamic game. Reaching the best implementable allocations involves realizing the endogenous value of an intrinsically worthless token and choosing with a forward-looking perspective. Responses in CRT and cognitive abilities in general correlate with strategic behavior (Gill and Prowse, 2016; Basteck and Mantovani, 2018; Bosch-Rosa *et al.*, 2018) and, in particular, support the achievement of Pareto superior results in both finite and indefinitely repeated interactions (Proto *et al.*, 2019; Grandjean *et al.*, 2022). We collect data from the CRT to investigate whether behavior, and in particular treatment effects, interact with the cognitive abilities of the participants.

[12]See Appendix A for a transcript of the cognitive reflection test.

The SVO measures social preferences using choices in 15 dictator games. The dictator unilaterally decides on the distribution of resources between oneself and a recipient. Due to the absence of strategic considerations, dictator games are well suited to reveal the dictator's true social preference. In the SVO, the set of possible distributions is manipulated such that the choices reveal different dimensions of social preferences, including self-interest, competitive preferences, inequity aversion, altruism or efficiency care. Choices in the SVO are typically aggregated into a single measure, the SVO angle, that summarizes the prevailing motivations for the individuals, and often discretized into commonly observed preference types. The task is incentivized. In particular, we implement the random dictatorship version of the SVO. Participants are matched in pairs at random. All participants make their decisions as if they were dictators. In the end, the computer selects one in each pair as the dictator. The other is the recipient. The computer then selects one of the 15 allocation decisions and implements the allocation chosen by the dictator. Each participant could earn between USD 0.75 and USD 5 depending on the selected game and the dictator's decision.[13]

Behavior in SVO correlates with cooperative strategies in social dilemmas (Thielmann *et al.*, 2020; Van Dijk and De Dreu, 2021; Bilancini *et al.*, 2022; Alós-Ferrer and Garagnani, 2020). In our economy, production can occur only through the exchange of tokens. Nevertheless, we cannot rule out that participants are sustaining production as a form of gift-exchange/cooperative strategies or because they care about efficiency, i.e., they do not care about the transfer of the token. We collect data from the SVO to investigate whether production, and in particular treatment effects, interact with the social preferences of the participants.

4.4 Procedures

The experiment was conducted at the Indiana University IELab in Bloomington between October 31, 2024 and April 8, 2025. We ran 24 sessions, 6 for each treatment, and 8 participants participated in each session. Upon arrival and after reading the study information sheet, participants were randomly assigned to computer stations in the laboratory. They then read the instructions for the main task and completed a control quiz to ensure comprehension. Incorrect responses triggered automatic feed-

[13] See Appendix A for the instructions given for the SVO and the details of the 15 dictator games.

back that explained the error.

The sessions lasted on average 1 hour and 35 minutes in total, with the main task lasting about 45 minutes. At the end of each sequence, a new sequence began if time allowed. Across sessions, 2 to 3 sequences were implemented depending on their duration achieved and the pace of the participants. On average, a sequence lasted 10.56 payoff-relevant periods, with a median of two sequences per session. Following the main task, participants completed an exit survey that asked open-ended responses about their strategies and experience, followed by standard CRT and SVO items. The instructions for each task were shown on the screen before the task.

Finally, participants received a summary of their earnings for each task, completed a brief final survey asking for their gender, field of study, and risk attitudes, and proceeded to receive their payment. Each participant earned a USD 5 show-up payment, in addition to the earnings in the three tasks. The average payment was USD 25.89, comprising USD 15.30 for the main task, USD 1.94 for the CRT, and USD 4.07 for the SVO.

5 Findings

Our main hypothesis (hypothesis 1) is that digital currency enables production when money is misallocated, specifically when it is held by the producer, while this is not possible with cash. We tested for this hypothesis, with and without suggestion, considering two outcome variables: the quantity produced and the probability of producing a positive amount. Our main tests are non-parametric, and, in particular, we opt for two-sided randomization tests, which are well suited for the number of independent observations we have. All tests are conducted using one independent observation per session. To avoid over- or underweighting sequences of different lengths, in all tests, figures, and statistics, we only take into consideration the first ten periods of each sequence, which are always played given our block-random termination rule.[14] We report the results of alternative econometric analyses in Appendix B and reference them in the text when appropriate.

[14]Results are robust to considering all periods. The Figures including all periods are reported in Appendix B.

5.1 Production across treatments

In monetary equilibrium, production should be the same in all treatments when the consumer holds the token.When the producer has the token, however, production should be higher with digital currency than with cash. Figure 1 reports, for each treatment, the average quantity produced in matches where the consumer holds the token and in those where the producer holds the token.

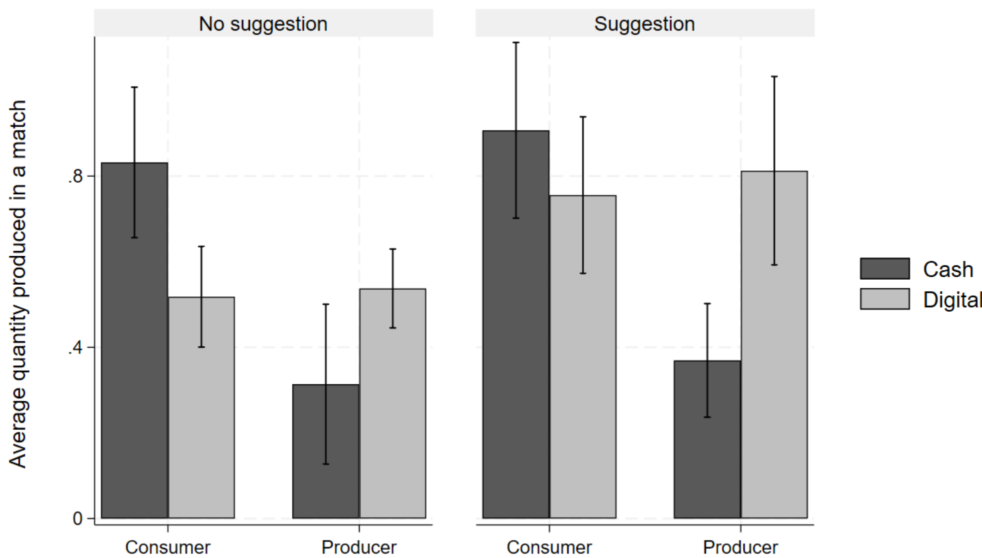

Figure 1: Quantities produced in consumer and producer meetings, by treatment

Note: Average production and 95% confidence interval for meetings where the Consumer has the token ('Consumer') and meetings where the Producer has the token ('Producer'), by treatment. Only the first ten periods of each sequence are considered. C.I. compute using one observation per session.

Figure 1 provides some support for the hypothesis that when the producer holds the token, production is higher with digital currency, namely in $D0$ (0.517 units) and $D1$ (0.814 units) than in $C0$ (0.305 units) and $C1$ (0.340 units). Figure 1, however, also suggests that production is higher with cash than with digital currency when the consumer holds the token, especially when there is no suggestion ($C0$: 0.808, $D0$: 0.461; $C1$: 0.873, $D1$: 0.799), despite the fact that theory does not predict any difference. For each type of match, we test for these differences using a two-sided randomization test. The test takes the observed difference in the average (or median) production between treatments and compares it to the distribution of differences obtained by permuting treatment labels (in our case, we run all possible permutations). The test confirms that, without suggestion, production is significantly higher with cash in consumer meetings ($p = 0.0130$). In producer meetings, production is lower with cash ($p = 0.0628$). With suggestion, there are no significant differences in production between the two treatments in Consumer meetings ($p = 0.3117$), and production is significantly higher with digital currency in Producer meetings ($p = 0.0108$). We reach identical conclusions when testing for differences between the medians, which are less sensitive to the presence of outliers among the sessions. Similar results also hold for the probability of producing positive amounts (Consumer meetings: $C0$ vs $D0$, $p = 0.0173$; $C1$ vs $D1$, $p = 0.2251$; Producer meetings: $C0$ vs $D0$, $p = 0.0108$; $C1$ vs $D1$, $p = 0.0065$).

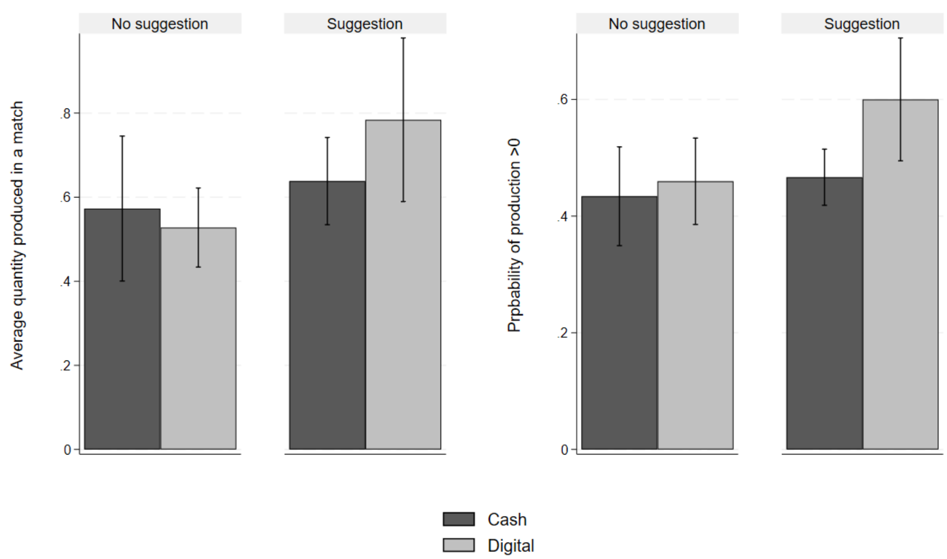

Figure 2: Overall quantities produced and probability of positive production, by treatment

Note: Average production (left panel) and probability of positive production (right panel) with 95% confidence interval, by treatment (aggregate over Consumer and Producer meetings). C.I. computed using one observation per session. Only the first ten periods of each sequence are considered.

Those differences are reflected in the overall efficiency of the economies. Figure 2 reports the average quantity produced (left panel) and the probability of producing a positive quantity (right panel) in a match for each treatment. The average production is slightly higher in $C0$ (0.557) than in $D0$ (0.532), but this difference is not significant ($p = 0.4870$), and the same holds for the probability of producing a positive amount ($p = 0.8766$). With suggestion, the average production is 27.3% higher in $D1$ (0.772) than in $C1$ (0.606). The median economy produces 40% more in $D1$ (0.812) than in $C1$ (0.578). However, the difference in the median is statistically significant only at the 10% level ($p = .0758$) and the difference in the average is not statistically significant ($p = 0.1450$). The difference in the probability of producing a positive amount between $C1$ and $D1$ is, instead, significant ($p = 0.0390$). Alternative testing strategies provide similar results (see Appendix B, Tables B.1 and B.2). Overall, the suggestion generates data that are closer to the monetary equilibrium, in particular with the digital currency. As a consequence, the outcomes of cash and digital currency are further apart when there is the suggestion.

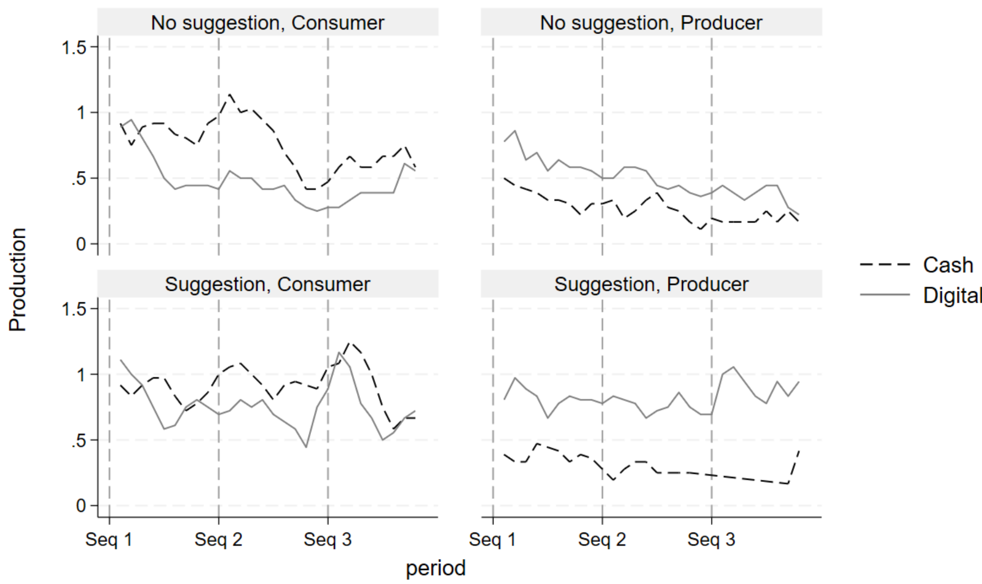

Figure 3: Production over periods, by type of meeting and treatment

Note: 3-period moving average of production in each treatment for the first ten periods of each sequence and for each type of meeting: C vs D in each panel; top panels: treatments with no suggestion ($C0, D0$); bottom panels: treatments with suggestion ($C1, D1$); left panels: Consumer meetings; right panels: Producer meetings.

We also observe meaningful differences in the dynamics of the data across treatments. Figure 3 shows how production varies over periods within a session, for each type of meeting. The Figure reports the 3-period moving average for the first ten periods of each sequence. Without suggestion, the difference between $C0$ and $D0$ reduces over time both for consumer meetings, where the digital currency leads to lower production than cash, and for producer meetings, where the digital currency leads to higher production. With suggestion, the difference for consumer meetings fluctuates, but then decreases to zero. The difference for the producer meetings is stable. If anything, it increases in the third sequence. These dynamics reinforce the idea that the suggestion is crucial to reap the benefits of the digital currency.

We summarize our findings as follows.

Result 1 *The experimental evidence supports hypothesis 1: a. In Producer meetings, production is higher in treatments $D0$ and $D1$ than in $C0$ and $C1$; b. The difference in production is larger between treatments $D1$ and $C1$ than between $D0$ and $C0$.*

We conclude that digital currency can increase production and efficiency when money is misallocated, provided that coordination on the monetary equilibrium is made easier by the presence of the suggestion to accept the token as a mean of exchange in the consumer meeting.

5.2 Proposals, acceptance rates and the value of currency

Here, we explore the mechanisms driving Result 1. In particular, our aim is to better understand the differences between treatment conditions with and without suggestion.

Theory predicts that there can be production in meetings where the consumer does not have a token in the treatment with digital currency, since the currency holders are incentivized to transfer it by the threat of the taxation of idle balances. However, in the experiment, it turns out that this effect makes a difference only when accompanied by the suggestion. When there is no suggestion, although production increases in meetings in which the producer holds the token, the effect is offset by a corresponding decrease in production in meetings where the consumer holds the token.

To better understand this pattern, we investigate participants' proposals and acceptance rates. Figures 4 and 5 indicate that consumers are less likely to ask the producer to produce two units, while producers are more likely to propose to produce at least one unit in $D0$ and $D1$ relative to cash treatments. This latter difference translates directly into different production levels when the producer has the token. This is because positive proposals by producers are always accepted by consumers. However, the former difference is not sufficient to explain the lower production that we observe in $D0$ relative to $C0$, in meetings where the consumer holds the token.

To make sense of this pattern, we consider the extent to which consumer proposals are accepted. Figure 6, clearly shows that digital currency is less accepted as a means of exchange than cash, especially when comparing $C0$ and $D0$.

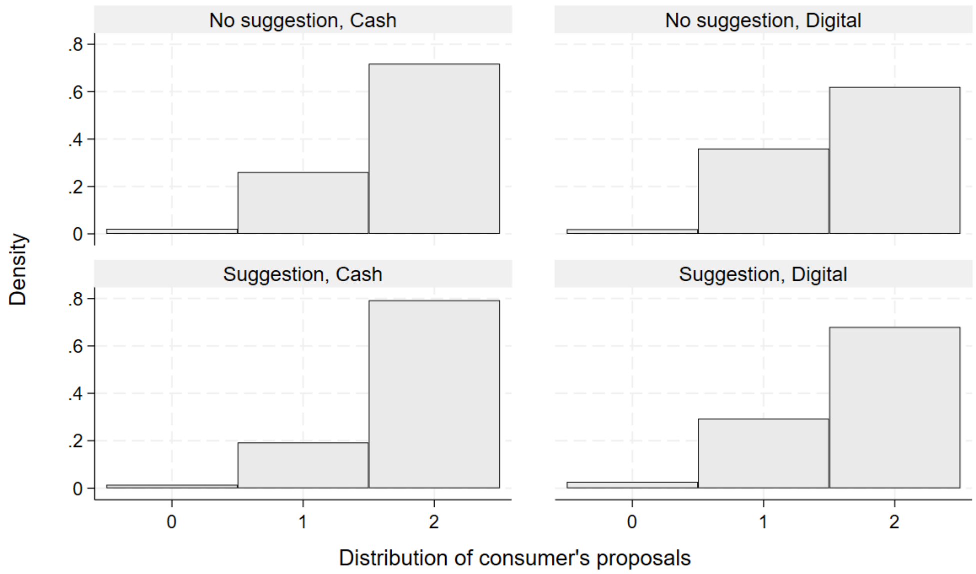

Figure 4: Distribution of consumers' proposals, by treatment

Note: Distribution of initial proposals by Consumers with token (first ten periods of each sequence). $0, 1, 2$ units would be produced if proposal is implemented. Top panels: treatments with no suggestion ($C0, D0$); bottom panels: treatments with suggestion ($C1, D1$); left panels: cash ($C0, C1$); right panels: digital ($D0, D1$).

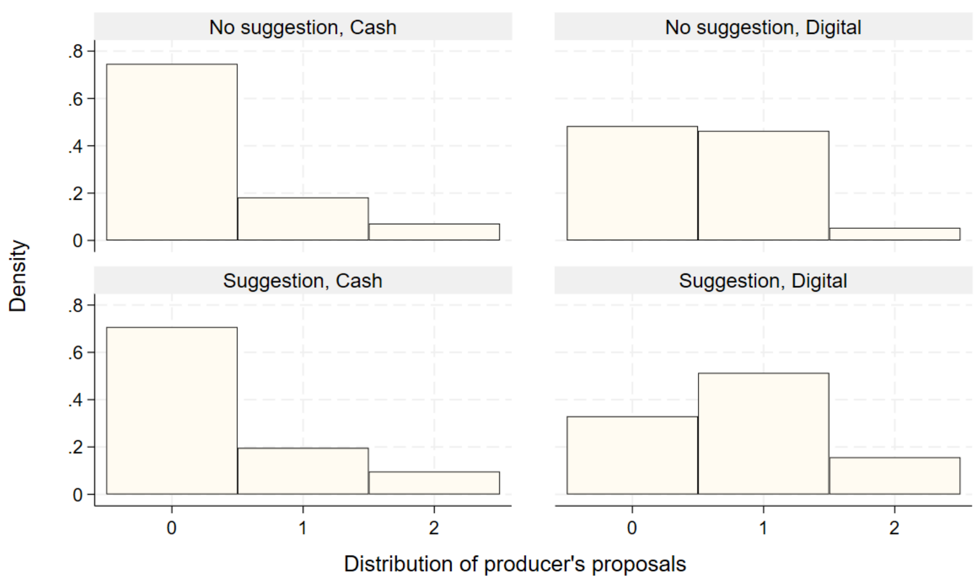

Figure 5: Distribution of Producers' proposals, by treatment

Note: Distribution of initial proposals by Producers with token (first ten periods of each sequence). $0, 1, 2$ units would be produced if proposal is implemented. Top panels: treatments with no suggestion ($C0, D0$); bottom panels: treatments with suggestion ($C1, D1$); left panels: cash ($C0, C1$); right panels: digital ($D0, D1$).

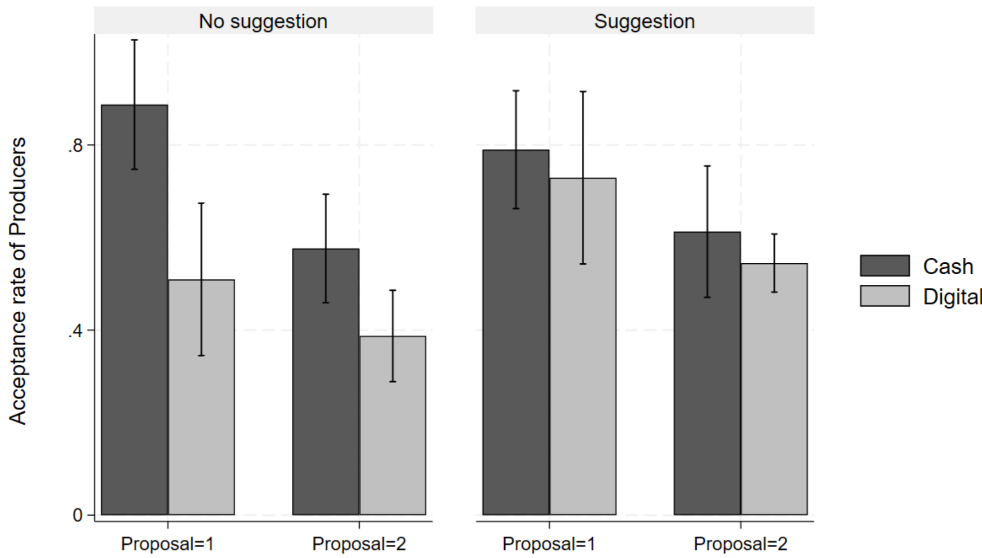

Figure 6: Acceptance rates of Producers

Note: Rate of acceptance of the Consumers' proposals by Producers when the Consumer has the token, with 95% confidence interval, in each treatment. $0, 1, 2$ refer to the units that would be produced if the proposal is accepted. Left panel: treatments with no suggestion ($C0, D0$); right panel: treatments with suggestion ($C1, D1$). The acceptance rate for the Producer meetings is not reported as the Consumers always accept when Producers propose to produce positive amounts. Only the first ten periods of each sequence are considered. C.I. computed using one observation per session.

Without suggestion, while cash is accepted around two-thirds of the time by producers, digital currency is only accepted about 45% of the time. The difference in acceptance rates is significant according to the two-sided randomization test ($p = .0173$). Differences are smaller and not significant with suggestion ($p = .2251$). We interpret this result by integrating insights from theory and data. Since acceptance rates give value to the token, lower acceptance rates decrease the value of digital currency relative to the cash economy. We know that this is the case, according to theory, even in equilibrium, when the conditional tax is never implemented, because consumers can consume even when they do not have the token in environments with digital currency. In the experiment, the conditional tax is sometimes levied, and hence the token is confiscated, further depressing the real value of digital currency. The expectation that people may not accept digital currency for this reason reinforces the effect. This also explains why the suggestion affects the outcomes in the digital currency economy but not in the cash economy. The suggestion helps to coordinate expectations in such a way that the token is accepted when the consumer holds it. The expectation that the token will be accepted increases its value also for the producers, stimulating production when the producer has the token. Consistently, acceptance rates increase significantly with suggestion under digital currency ($p = .0476$) and not under cash ($p = .6948$).

We also consider whether individual characteristics help to understand behavior and treatment effects (see Table B.3 in Appendix B). Producers that are prosocial in the SVO produce more and accept the token more often. In addition, producers with higher cognitive abilities, as measured by CRT, produce more. This is presumably due to their greater ability to anticipate the strategic future benefits of production. Less risk averse participants accept the token more often (paying a certain cost in exchange for an uncertain future benefit) and propose to produce more as Consumers (while the opposite holds for participants that make more mistakes in the control quiz). We do not observe any effect of demographics such as age and gender. Although these effects are intuitive, treatments are generally balanced in terms of individual characteristics (see Table B.4 in Appendix B) and cannot explain treatment differences.

6 Conclusion

In this paper, we have contrasted decentralized trade with digital currency and cash, the key difference being the traceability of the former but not the latter. Traceability can help stimulate liquidity transfers, thus increasing output and welfare; however, it may make implementation more difficult compared to cash. The laboratory experiment confirms that digital currency can improve the allocation of resources relative to cash, with the important caveat that the implementation of a system based on digital currency, at least initially, should be actively supported by the authorities.

We have considered a scenario in which currency transfers are incentivized, threatening to tax idle balances. An obvious alternative, explored theoretically by Amendola *et al.* (2025a) in a Lagos and Wright (2005) model, would be to pay interest on active balances. Testing this possibility in the lab with nominal interest rates requires setting up a more elaborate model with divisible currency and goods and is left for future research. Arifovic *et al.* (2025) integrate theory and experiments to study the interaction between currency competition and monetary policy in an environment where currencies do not differ technologically. Future research could explore the co-existence of cash and digital currency, or the comparison of sovereign and private digital currencies.

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A Experimental Instructions

Instructions

Welcome to this experiment in the economics of decision-making. During the session, you will make a series of decisions. Today's session has three parts. In each part, you will make a series of decisions. The earnings you will make from the three parts will be calculated in points, and will be converted into dollars at the specified exchange rates. In addition, you will also receive a $5 show-up payment regardless of your earnings during the experiment. If you follow the instructions carefully, you can earn a considerable amount of cash. Between the three parts, you will be required to complete short surveys. *Please refrain from talking for the duration of today's session. Kindly silence all mobile devices.*

Overview

There are eight participants in today's session. Each participant will make consuming, producing, buying and selling decisions in a number of *sequences*. Each sequence consists of an unknown number of *periods* (more on this below). There are two objects: a token and a good. The good is perishable, i.e., it cannot be brought from the current period to the following period. Tokens are durable and can be brought from the current period to the following period within a sequence. You earn points from consuming the good and lose points from producing it. The token itself does not yield points directly (it cannot be directly redeemed for points or dollars at the end of the experiment) but may help you earn points if other participants are only willing to produce for you in exchange for the token.

Timing

Today's session consists of several sequences, which are further broken down into an uncertain number of periods.

1. The number of periods in a sequence is determined as follows. At the end of each period, the computer draws a random integer between 1 and 10 to determine whether the sequence will continue or not.

    - If the number drawn is between 1 and 9 (inclusive), the sequence continues.
    - If the number drawn is 10, the sequence ends. This means after each period, there is always a 90% chance the sequence continues to a new period and a 10% chance the sequence ends.

2. The first 10 periods of a sequence are called a block. In a block, you will make decisions without knowing the realization of the random numbers, even if the number "10" has been drawn.

3. At the end of a block, you learn the realization of the random draws for all 10 periods in the block and therefore whether the sequence has actually ended.

   - If the number "10" is drawn anytime within the block, the sequence has ended. The final period of the sequence is the first period where "10" is drawn. Your decisions after the final period are ignored and do not count towards your final earnings.

   - If the number "10" is not drawn anytime within the block, the sequence continues to period 11. From period 11 onward, you will be informed of the realization of the random draws at the end of each period. As described above, the final period of the sequence is reached once"10" is drawn.

4. Depending on the time available, we may start a new sequence when a sequence ends.

At the end of the session, the point total from all sequences will be converted to cash. We now describe in detail how the tokens are distributed and the choices you make in each period.

Token Distribution

At the beginning of each sequence, half of the participants are endowed with one token each. Each participant can hold at most one token.

Pairing Procedure

At the beginning of each period, each participant with a token is randomly paired with another participant without a token. In each pair, one participant is chosen to be the **Consumer** and the other is the **Producer** so as to generate two types of equally likely pairings: either a Consumer with a token is paired with a Producer without a token, or a Consumer without a token is paired with a Producer with a token. In every period, you are equally likely to be a Producer or Consumer. Because you are randomly paired across periods, the person you are paired with is likely to change from period to period.

In each period, a "perishable" good can be produced by Producers and traded to Consumers. This good is "perishable" because it cannot be carried over into another period. Each Producer can produce either **0**, **1**, or **2** units of the good in each period. Consumers receive a benefit of 7 points from each unit they consume of the good, which is added to their point total. For example, if you are a Consumer and you succeed in consuming one unit, you get a benefit of 7 points; if you succeed in consuming 2 units, you get a benefit of 14 points. Producers incur a cost of 1 in points per unit of the good, which is subtracted from their point total. For example, if a producer agrees to produce one unit, s/he loses 1 point, while if s/he agrees to produce two units, s/he loses 2 points. See Table A.1 for benefits and costs in points for consumers and producers.

Quantity	Consumer's Benefit	Producer's Cost
0	0	0
1	7	1
2	14	2

Table A.1: Benefits and Costs (in Points) for Consumers and Producers

Timing and Decisions in Each Period

Recall that in each pair, either the Consumer or the Producer has the token. The participant who holds the token moves first.

Case 1: The Consumer holds the token

- If the Consumer holds the token, s/he moves first and must decide whether to keep the token or transfer it to the Producer in exchange for the good.
- If the Consumer decides to keep the token, then no exchange takes place. There is no production or consumption. [$D0, D1$ However, the token will be confiscated from the Consumer and assigned to one of the other participants without a token, with an equal chance for each such participant.]
- If the Consumer decides to transfer the token to the Producer, then s/he also must decide whether s/he wants her/his matched Producer to produce for her/him either 1 or 2 units.
  - After the Consumer has made her/his proposal, it is the Producer's turn to decide whether to "Accept" the Consumer's proposal, "Reject" the Consumer's proposal, or "Make a Different Proposal."
  - If a Producer clicks the Accept button, the proposed exchange takes place: the Producer produces the requested number of units of the good, incurs a cost in

points from doing so, but receives the token from the Consumer. The Consumer receives a benefit in points from the consumption of the good but transfers the token to the Producer.

- If the Producer clicks the Reject button, then no exchange takes place. There is no production or consumption. [$D0, D1$ However, the token will be confiscated from the Consumer and assigned to one of the other participants without a token, with an equal chance for each such participant.]
- If the Producer clicks the Make a Different Proposal button, the Producer specifies how many units s/he is willing to produce in exchange for the token. The Consumer is then presented with this new proposal and may 1) Accept it, in which case the exchange is implemented as described above, 2) Reject it, in which case no exchange takes place, [$D0, D1$ and the token is confiscated from the Consumer] or 3) Make a Different Proposal to the Producer. If the Consumer makes a different proposal to the Producer's proposal, then the Producer must either 1) Accept or 2) Reject that proposal; following a maximum of three rounds of proposals, with the Consumer making the last proposal, there are no further opportunities to make proposals. If no proposal is accepted, there is no production [$D0, D1$ and the token is confiscated and reassigned].

[$C1, D1$

- A suggestion:

  The Consumer and Producer may consider making the following choices:

  - The Consumer transfers the token to the Producer
  - The Producer produces in exchange for the token

  This is simply a suggestion. Feel free to follow it or not.]

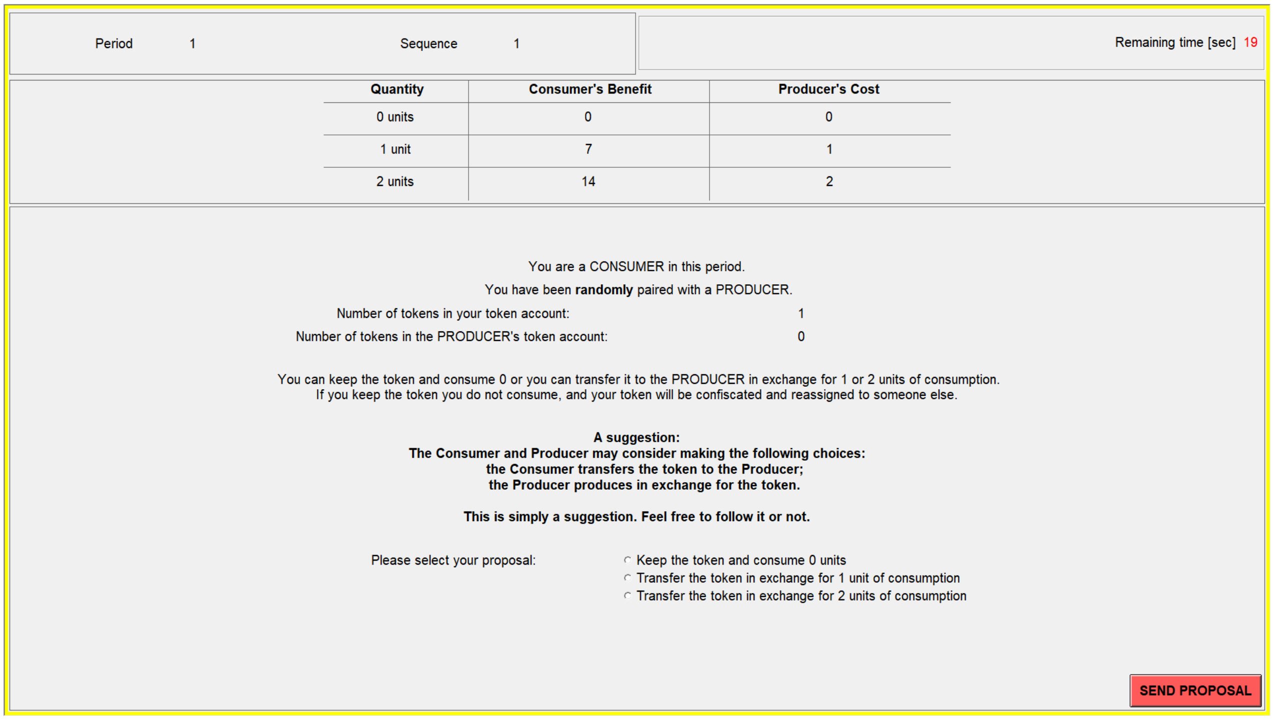

Figure A.1: Sample screen: the consumer makes a proposal

Case 2: The Producer holds the token

- If the Producer holds the token, s/he moves first and must decide whether to keep the token or transfer it to the Consumer.
- If the Producer decides to keep the token, then no exchange takes place. There is no production or consumption. [$D0, D1$ However, the token will be confiscated from the Producer and assigned to one of the other participants without a token, with an equal chance for each such participant.]
- If the Producer decides to transfer the token to the Consumer, then s/he needs to produce to receive the token back. Specifically, s/he must also decide whether s/he is willing to produce either 1 or 2 units to receive the token back. It is not possible to receive the token back without producing for it.
  - After the Producer has made her/his proposal, it is the Consumer's turn to decide whether to "Accept" the Producer's proposal, "Reject" the Producer's proposal, or "Make a Different Proposal."
  - If a Consumer clicks the Accept button, the proposed exchange takes place: the Producer produces the proposed number of units of the good, incurs a cost in

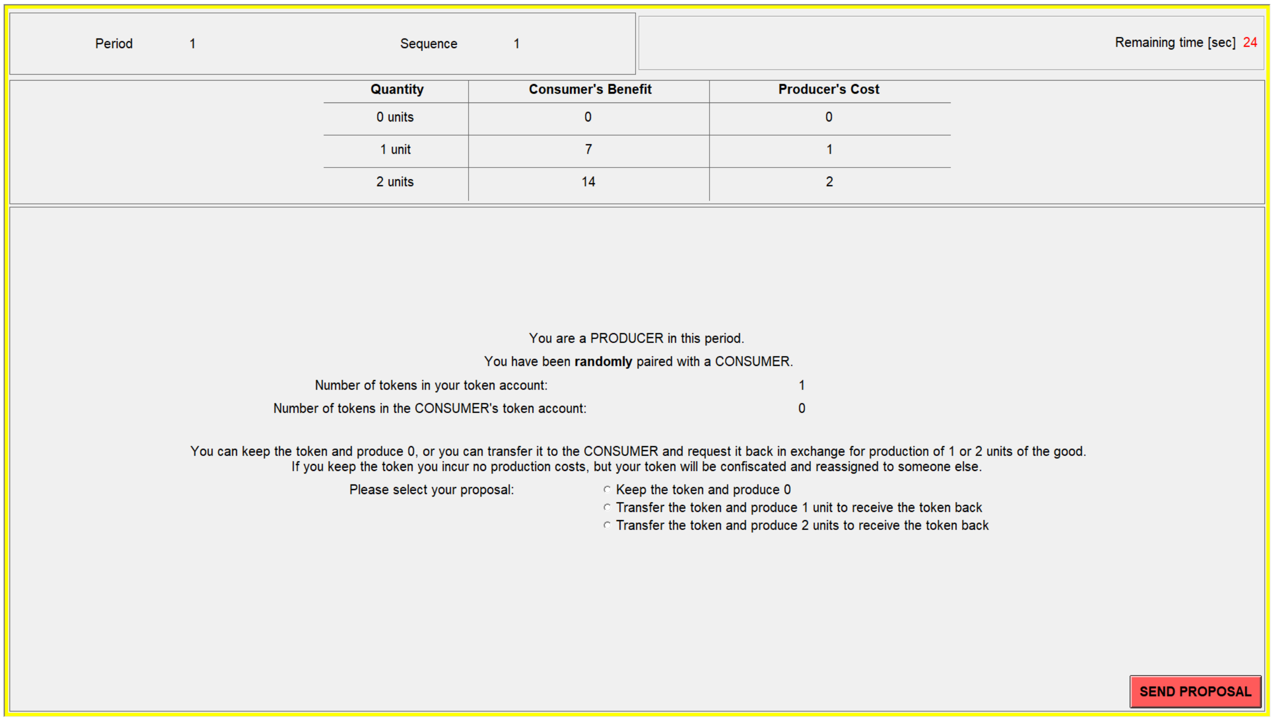

Figure A.2: Sample screen: the producer makes a proposal

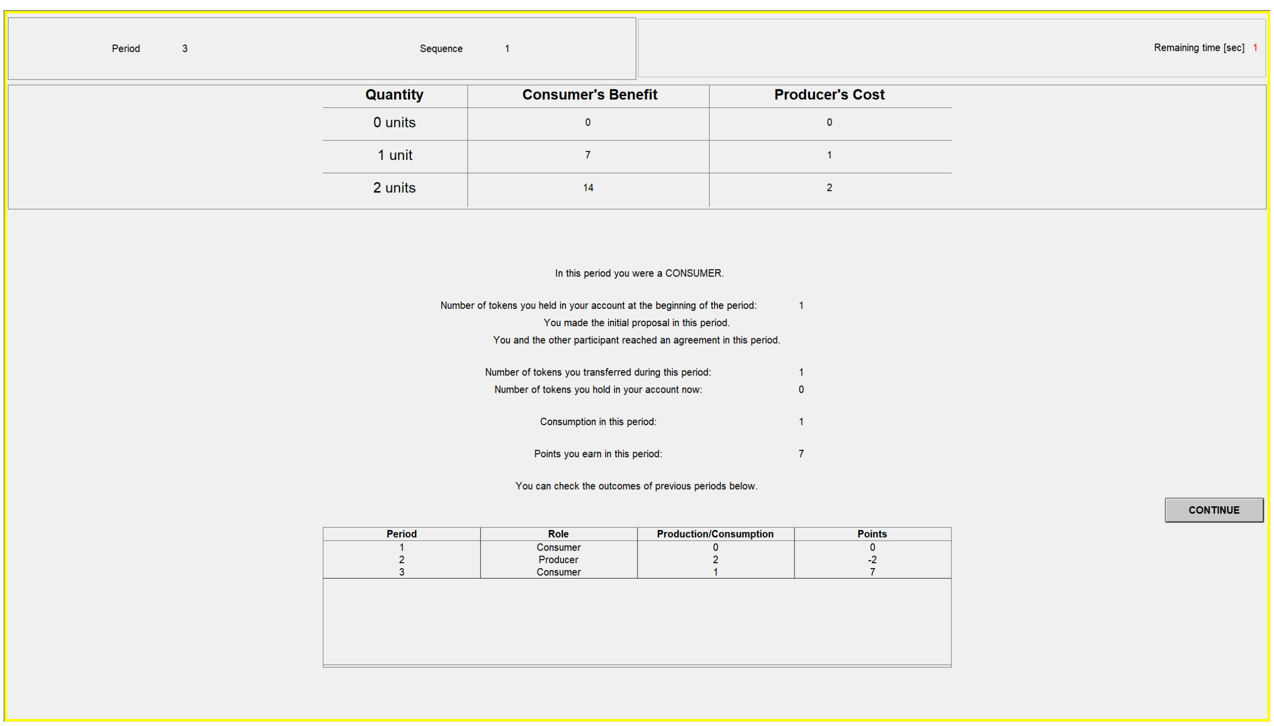

Figure A.3: Sample screen: feedback after each round points from doing so, but receives the token back. The Consumer receives a benefit in points from the consumption of the good but transfers the token back to the Producer.

- If the Consumer clicks the Reject button, then no exchange takes place. There is no production or consumption. [$D0, D1$ However, the token will be confiscated from the Producer and assigned to one of the other participants without a token, with an equal chance for each such participant.]
- If the Consumer clicks the Make a Different Proposal button, the Consumer specifies how many units s/he wants her/his matched Producer to produce for her/him in exchange for the token. The Producer is then presented with this new proposal and may 1) Accept it, in which case the exchange is implemented as described above, 2) Reject it, in which case no exchange takes place [$D0, D1$ and the token is confiscated from the Producer], or 3) Make a Different Proposal to the Consumer. If the Producer makes a different proposal to the Consumer's proposal, then the Consumer must either 1) Accept or 2) Reject that proposal; following a maximum of three rounds of proposals, with the Producer making the last proposal, there are no further opportunities to make proposals. If no proposal is accepted, there is no production [$D0, D1$ and the token is confiscated and reassigned].

After all decisions have been made, the results of each period are revealed. Any exchanges are implemented and you move on to the next period if there is one.

Earnings

You will start every sequence with an endowment of 5 points. In each sequence your points total increases by 7 points for every unit you consume, and decreases by 1 point for every unit you produce. Your points from all sequences will be converted into dollars at rate 1 point = \$0.25.

Summary

1. Each sequence is composed of an uncertain number of periods.

2. In every period you are randomly paired with another participant. Therefore, the participant you are matched with is likely to change from period to period.

3. There are two objects: a token and a good. The good is perishable, i.e., it cannot be brought from the current period to the following period. The token is durable, i.e., it can be brought from the current period to the following period.

4. In every period, half of the participants hold one token each. At the beginning of each period, each participant with a token is matched with a participant without a token.

5. In each pair, one participant is randomly chosen to be the Consumer and the other the Producer so as to generate two types of equally likely pairings: either a Consumer with a token is paired with a Producer without a token, or a Consumer without a token is matched with a Producer with a token.

6. The token itself does not yield points directly but may help you earn points if other participants are willing to produce for you in exchange for the token.

7. The Consumer earns 7 points for each unit s/he consumes of the good.

8. The Producer loses 1 point for each unit s/he produces of the good.

9. In every period and in every pair, the participant who holds the token moves first and makes a proposal to the other participant. The other participant can accept it, reject it or make a different proposal.

10. If the Consumer holds the token s/he first decides whether to keep the token or transfer it in exchange for the good. If s/he decides to transfer the token, s/he must also ask the Producer to produce either 1 or 2 units in exchange for the token. If the Producer accepts the proposal, token and point balances will be updated accordingly. If the Producer rejects the proposal, no exchange will take place. There is no production or consumption. [$D0, D1$ However, the token will be confiscated and assigned to one of the other participants without a token with an equal chance for each such participant.] If the Producer makes a different proposal, the Consumer can accept it, reject it or make the final proposal.

[$C1, D1$ 11. In the meeting where the Consumer holds the token, the Consumer and Producer may consider making the following choices: i) The Consumer transfers the token to the Producer; and ii) The Producer produces in exchange for the token. This is simply a suggestion. Feel free to follow it or not.]

12. If the Producer holds the token s/he first decides whether to keep the token or transfer it. If s/he decides to transfer the token, then s/he must choose whether to produce 1 or 2 units for the Consumer to receive the token back. If the Consumer accepts the proposal, token and point balances will be updated accordingly. If the Consumer rejects the proposal, no exchange will take place. There is no production or consumption. [$D0, D1$ However, the

token will be confiscated and assigned to one of the other participants without a token with equal chances for each such participant.] If the Consumer makes a different proposal, the Producer can accept it, reject it or make the final proposal.

13. At the end of every period, there is a 9 in 10 chance that the sequence continues with a new period. Otherwise, the sequence ends and a new sequence may begin.

14. You play the first ten periods of a sequence without knowing whether the sequence has ended in some period or not. If it does not end within ten periods, you are then informed after every period on whether the sequence continues or ends.

15. Your point total from all sequences is converted into Dollars and paid to you privately.

B Further results and robustness

In this appendix, we report additional results and robustness checks.

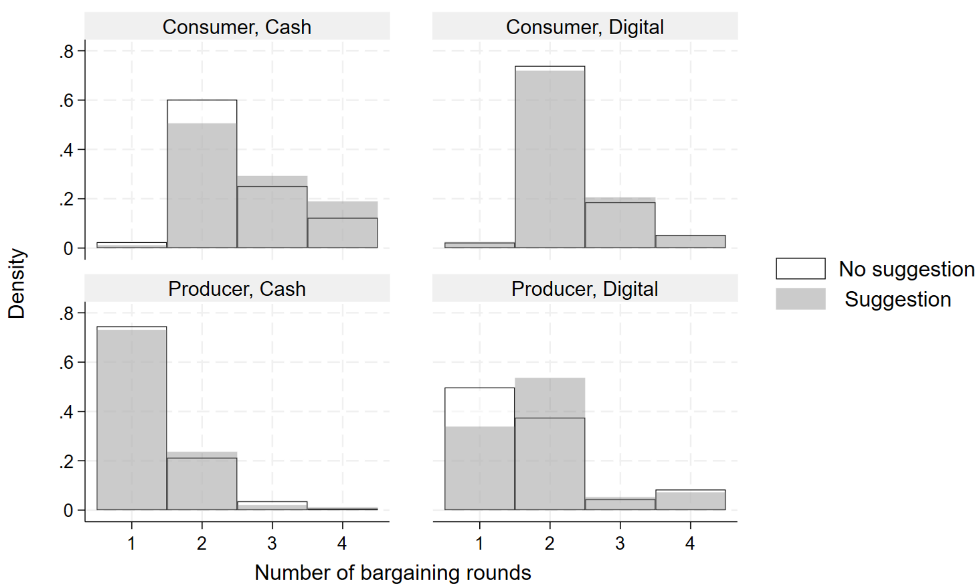

Figure B.1: Distribution of bargaining rounds

Note: distribution of the actual number of rounds of bargaining. 0 means the initial proposer decided to keep the token and produce zero; 1 means a proposal involving positive production was made and was either accepted or rejected; 3, 4 mean that one or two counter-proposals were made after the initial one. Top panels: Consumer meetings; bottom panels: Producer meetings; left panels: cash ($C0, C1$); right panels: digital ($D0, D1$). In each panel, the white distribution is for the treatment with no suggestion, the shaded distribution is for treatment with suggestion.

Table B.1: Alternative testing strategy: rank-sum tests

	Cash vs Digital					
	Production: quantity			Probability(Production> 0)		
	Consumer	Producer	Aggregate	Consumer	Producer	Aggregate
No suggestion	.0152	.1061	.3939	.0152	.0108	.9372
Suggestion	.3290	.0108	.1797	.1926	.0087	.0649
	No suggestion vs Suggestion					
	Production: quantity			Probability(Production> 0)		
	Consumers	Producer	Aggregate	Consumer	Producer	Aggregate
Cash	.5584	.6255	.8182	.5628	.7381	.8182
Digital	.0931	.0498	.0649	.1027	.0584	.0931

Notes: The Table reports the exact p-values for a battery of across-treatment rank-sum tests. The top panel reports comparisons of cash and digital: $C0$ vs $D0$ in the first row; $C1$ vs $D1$ in the second row. The bottom panel reports on the effect of the suggestion: $C0$ vs $C1$ in the first row; $D0$ vs $D1$ in the second row. Left-hand columns: tests on the quantity produced. Right-hand columns: tests on the probability of producing positive amounts. 'Consumer': only meetings where the Consumer has the token. 'Producer': only meetings where the Producer has the token. 'Aggregate': all meetings. All tests are based on one independent observation per session.

Table B.2: Alternative testing strategy: regressions

	(1) production (producer meetings)	(2) production (consumer meetings)	(3) production (all meetings)	(4) P(prod> 0) (producer meetings)	(5) P(prod> 0) (consumer meetings)	(6) P(prod> 0) (all meetings)
Digital	0.211**	-0.347***	-0.0680	0.233***	-0.225***	0.00402
	(0.0982)	(0.109)	(0.102)	(0.0658)	(0.0372)	(0.0585)
Suggestion	0.0348	0.0644	0.0496	0.0209	0.0223	0.0216
	(0.116)	(0.111)	(0.0976)	(0.0775)	(0.0377)	(0.0506)
Digital*Suggestion	0.262*	0.205	0.234*	0.137	0.125**	0.131*
	(0.159)	(0.147)	(0.157)	(0.119)	(0.0525)	(0.0850)
_cons	0.305***	0.808***	0.557***	0.234***	0.617***	0.425***
	(0.0896)	(0.0898)	(0.0864)	(0.0623)	(0.0268)	(0.0468)
N	1392	1392	2784	1392	1392	2784

Notes: The Table reports regressions that estimate treatment effects. Models (1)-(3) have the number of units produced as the outcome variable. Models (4)-(6) have the probability of producing positive amounts as the outcome variable. We report estimates for Producer meetings (Models (1) and (4)), Consumer meetings (Models (2) and (5)) and both (Models (3) and (6)). Standard errors are bootstrapped and clustered at the session level. *,** and *** indicate significance at the .1, .05 and .01 level.

Table B.3: Regressions with individual characteristics

	(1) production (producer meetings)	(2) production (consumer meetings)	(3) accept (consumer meetings)	(4) First proposal (consumer meetings)
Digital	0.237**	-0.345***	-0.190***	-0.114
	(0.103)	(0.112)	(0.0701)	(0.129)
Suggestion	0.0965	0.0509	0.0595	0.0718
	(0.120)	(0.140)	(0.0529)	(0.113)
Digital*Suggestion	0.202	0.221	0.0740	0.000983
	(0.150)	(0.190)	(0.0838)	(0.173)
male	-0.00309	-0.0222	-0.0225	-0.00404
	(0.0547)	(0.0390)	(0.0404)	(0.0364)
prosocial	0.305***	0.00124	0.175***	0.00208
	(0.0480)	(0.0344)	(0.0352)	(0.0524)
risk propensity	0.0149	0.00539	0.0184*	0.0240**
	(0.0141)	(0.00798)	(0.0110)	(0.0110)
crt score	0.0854***	-0.0299**	0.0301	-0.0165
	(0.0289)	(0.0146)	(0.0198)	(0.0249)
quiz mistakes	0.416	-0.238	-0.244	-0.705***
	(0.280)	(0.150)	(0.197)	(0.229)
round	-0.0117***	-0.0305***	-0.0207***	-0.0213***
	(0.00439)	(0.00510)	(0.00265)	(0.00388)
_cons	-0.0932	1.117***	0.576***	1.811***
	(0.128)	(0.130)	(0.113)	(0.119)
N	1392	1392	1392	1392

Notes: The Table reports regressions that estimate treatment effects along with individual characteristics. Models (1)-(2) have the number of units produced as the outcome variable for Producer and Consumer meetings. Individual characteristics refer to the Producer in Producer meetings and to the Consumer in Consumer meetings. Model (3) has the probability that the Consumer's proposal is accepted in Consumer meetings. Individual characteristics refer to the Producer. Model (4) has the Consumer's proposal in Consumer meetings as the outcome variable. Individual characteristics refer to the Consumer. Standard errors are bootstrapped and clustered at the session level. *,** and *** indicate significance at the .1, .05 and .01 level.

Table B.4: Tests of balancedness across treatments

Variable	$C0$	$D0$	$C1$	$D1$	$C0$ vs $D0$	$C1$ vs $D1$
Age	21.5	21.5	21.2	21.5	.534	.526
Male	.625	.625	.479	.667	1.00	.040
Risk tolerance	6.89	5.85	5.92	6.33	.031	.416
CRT score	2.04	1.89	1.71	1.96	.831	.184
Prosocial	.458	.396	.396	.375	.680	1.00
Mistakes	.171	.172	.140	.171	.673	.324

Notes: The table reports the tests of balancedness of groups across treatments. *Age*: average reported age; test: rank-sum test. *Male*: fraction of males; test: Fisher's exact test. *Risk tolerance*: average self-reported risk propensity; test: rank-sum test. *CRT score*: average score in the CRT; test: Fisher's Exact test. *Prosocial*: fraction of prosocial participants according to the Social Value Orientation; test: Fisher's Exact test. *Mistakes*: average fraction of mistakes in the control quiz; test: rank-sum test. Uncorrected p-values in the last two columns

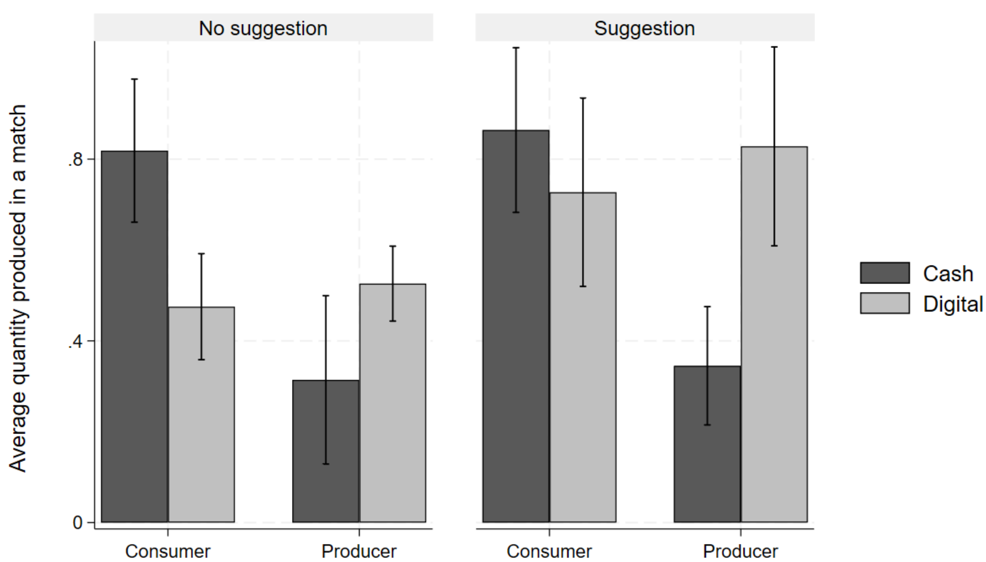

Figure B.2: Quantities produced in consumer and producer meetings (all periods), by treatment

Note: Average production and 95% confidence interval for meetings where the Consumer has the token ('Consumer') and meetings where the Producer has the token ('Producer'), by treatment. C.I. computed using one observation per session. The data from all periods are included.

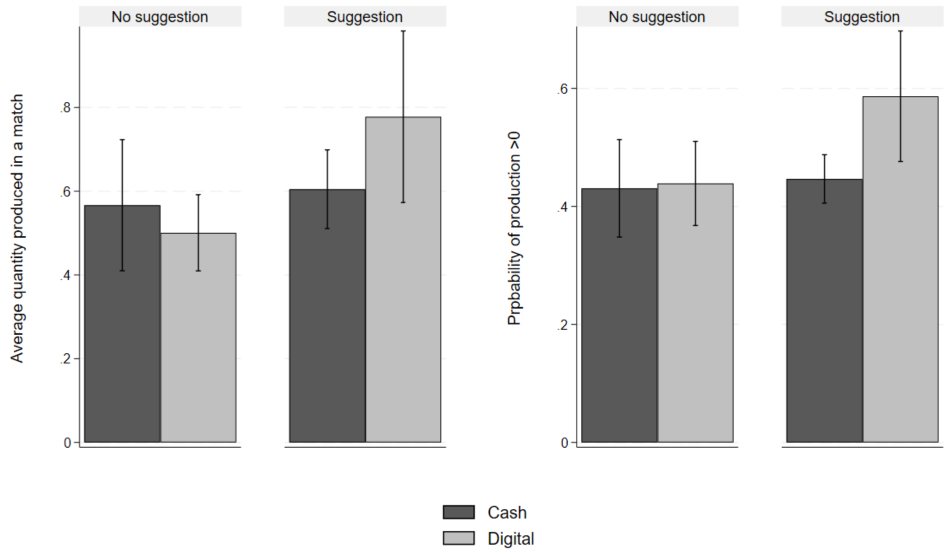

Figure B.3: Overall quantities produced and probability of positive production (all periods), by treatment

Note: Average production (left panel) and probability of positive production (right panel) with 95% confidence interval, by treatment (aggregate over Consumer and Producer meetings). C.I. computed using one observation per session. The data from all periods are included.

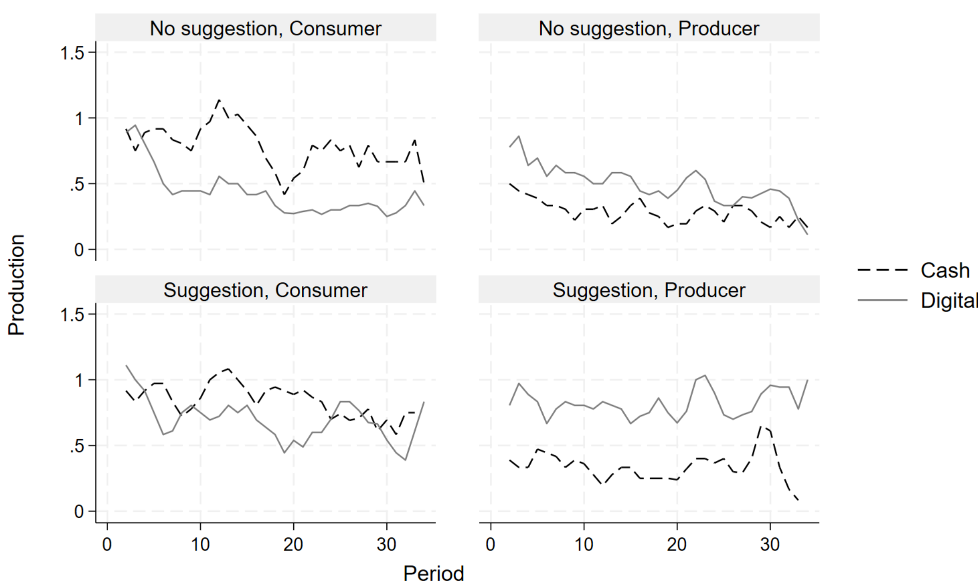

Figure B.4: Production over periods, by type of meeting and treatment (all periods)

Note: 3-period moving average of production in each treatment for each type of meeting (all periods included): C vs D in each panel; top panels: treatments with no suggestion ($C0, D0$); bottom panels: treatments with suggestion ($C1, D1$); left panels: Consumer meetings; right panels: Producer meetings.

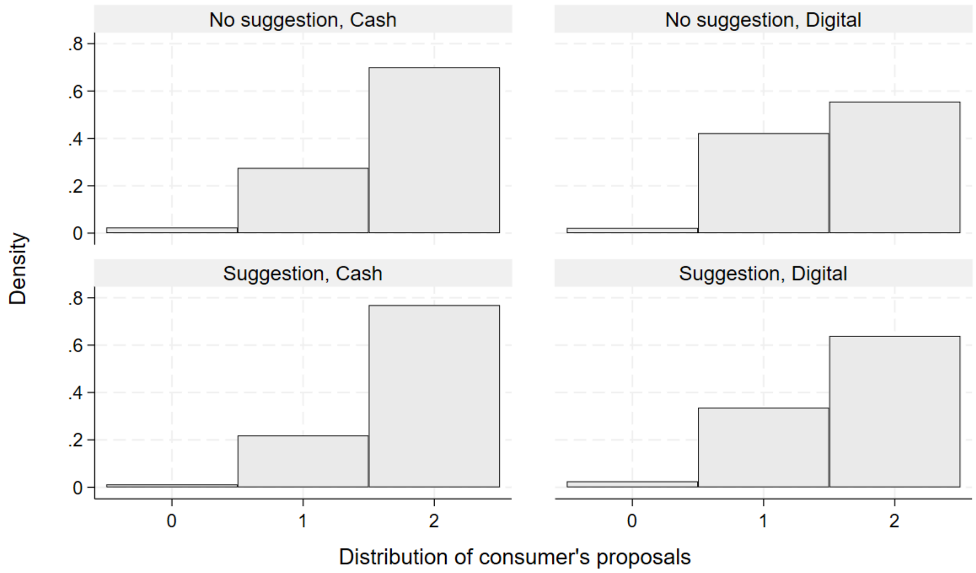

Figure B.5: Distribution of consumers' proposals, by treatment (all periods)

Note: Distribution of initial proposals by Consumers with token, all periods included. $0, 1, 2$ units would be produced if proposal is implemented. Top panels: treatments with no suggestion $(C0, D0)$; bottom panels: treatments with suggestion $(C1, D1)$; left panels: cash $(C0, C1)$; right panels: digital $(D0, D1)$.

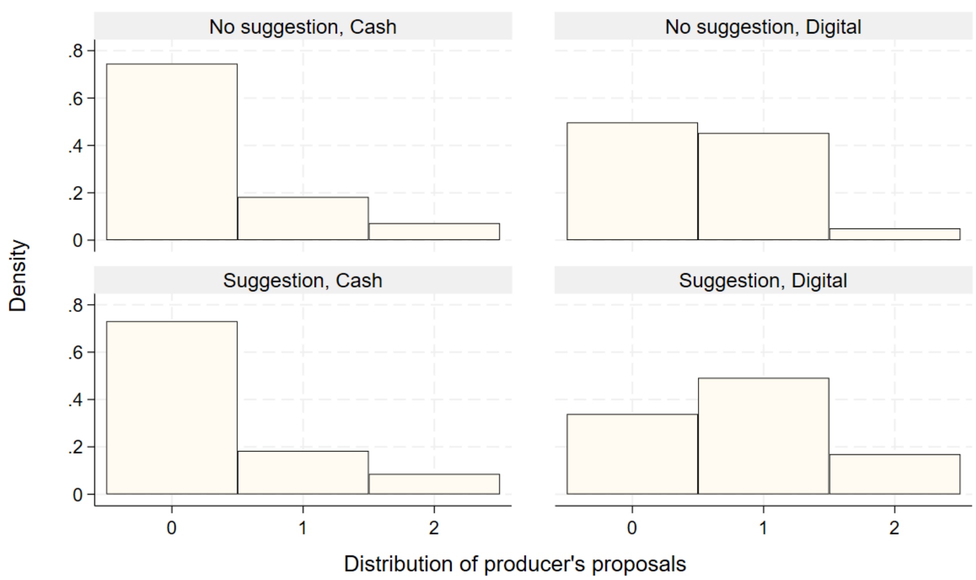

Figure B.6: Distribution of Producers' proposals, by treatment (all periods)

Note: Distribution of initial proposals by Producers with token, all periods included. $0, 1, 2$ units would be produced if proposal is implemented. Top panels: treatments with no suggestion $(C0, D0)$; bottom panels: treatments with suggestion $(C1, D1)$; left panels: cash $(C0, C1)$; right panels: digital $(D0, D1)$.

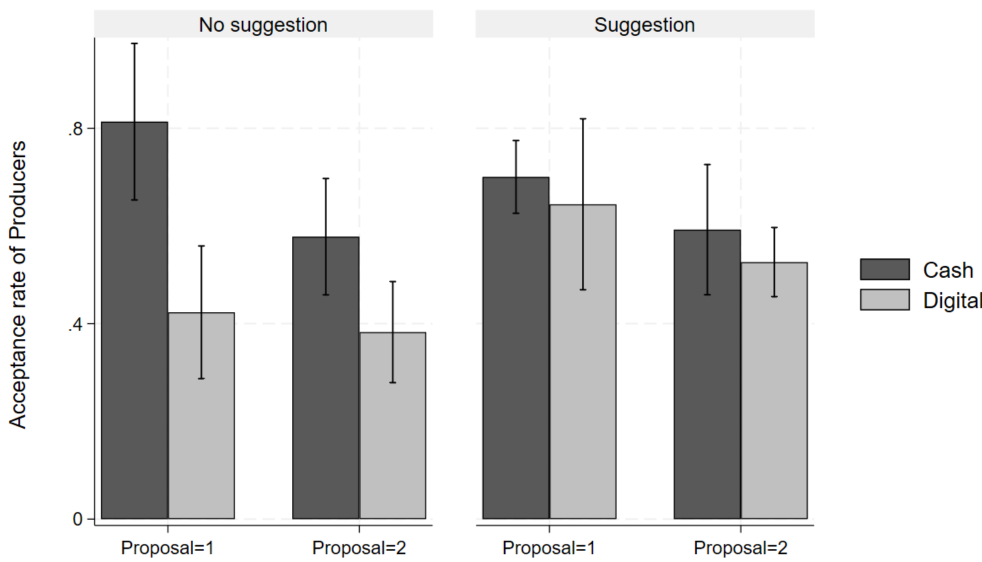

Figure B.7: Acceptance rates of Producers (all periods)

Note: Rate of acceptance of the Consumers' proposals by Producers when the Consumer has the token, with 95% confidence interval, in each treatment. $0, 1, 2$ refer to the units that would be produced if the proposal is accepted. Left panel: treatments with no suggestion ($C0, D0$); right panel: treatments with suggestion ($C1, D1$). The acceptance rate for the Producer meetings is not reported as the Consumers always accept when Producers propose to produce positive amounts. C.I. computed using one observation per session. All periods are considered.