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When less is more: behavioral effects of CBDC holding limits

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Abstract

Holding limits are a central design feature of proposed retail central bank digital currencies (CBDC). While such limits mechanically prevent individuals from exceeding a maximum balance, they may also generate behavioral responses whose directions are *a priori* unclear. We conducted an incentivized online experiment with participants from four euro-area countries, exogenously varying the presence and level of a holding limit to causally separate direct mechanical effects from behavioral effects. We find that behavioral responses increase holdings of the means of payment subject to the holding limit, consistent with an attraction effect. This effect is material only when the limit is high enough. Enabling reverse waterfall —automatic conversion into this limited means of payment— increases adoption while reducing holdings. These results suggest that combining holding limits with automatic funding mechanisms can support CBDC use while containing holdings, thereby helping to mitigate potential financial stability risks.

Keywords: CBDC, holding limits, digital currency, behavioral economics, experimental economics.

JEL codes: E42, C91, D14, E58.

Non-technical summary

Several central banks are exploring the possibility of issuing a central bank digital currency (CBDC) — a digital form of public money for everyday payments. The CBDC design needs to balance ease of use with ensuring that it preserves financial stability. In response, most CBDC projects foresee the introduction of a holding limit, which would cap the amount of CBDC that individuals could hold in their digital wallets. At the same time, automatic funding mechanisms such as the reverse waterfall functionality can allow individuals to make payments even when they do not hold sufficient CBDC, potentially reducing the need to hold large CBDC balances.

While holding limits would mechanically restrict how much CBDC people can hold, they may also have a behavioral impact. For example, some individuals may view the limit as a restriction of their decision rights, decreasing the attractiveness of the CBDC. For others, instead, the limit can act as a reference point, attracting CBDC holdings towards that value. Understanding these possible responses is important to assess how much CBDC people would actually hold and thus anticipate its impact on the financial system if such limits were introduced.

This paper investigates how holding limits influence individuals' choices about how to allocate their money between different payment instruments. In particular, it studies whether the introduction of a limit changes individuals' behavior beyond its direct mechanical effect. The analysis also provides empirical evidence on the reverse waterfall functionality. This mechanism automatically converts funds from a user's commercial bank account into CBDC whenever the user needs to make a payment but does not currently hold enough CBDC.

To disentangle the direct effect of the limit from its behavioral effects, the paper uses a controlled online experiment with 761 participants from four euro area countries: France, Germany, Italy, and Spain. In the experiment, participants made decisions about how to allocate tokens between two means of payment, then faced automated sellers, and earned money if they held the means of payment required by the seller. One instrument bears interest but is not always accepted, while the other pays no interest, is always accepted for payments and could be subject to a holding limit. These differences capture the essence of the differences between bank-card payment and CBDC, where the former can be remunerated via a deposit account and the latter can be used for peer-to-peer payments. Our

identification strategy relies on comparing participants' decisions in the absence and the presence of a limit, and assessing whether the level of the limit affects these behavioral responses by comparing decisions with relatively lower and higher limits. In addition, we investigate how the presence of a reverse waterfall functionality affects individuals' responses to these limits.

Our results show that holding limits can generate indirect behavioral effects. Participants whose initial holdings are below the limit, and thus would be expected to keep the same allocation in the absence of indirect effects, tend on average to increase their holdings when the limit is introduced. Moreover, distinguishing between relatively lower and higher limits, we find that this increase in holdings emerges only when the limit is higher due to an asymmetric impact of attraction and repulsion. When the limit is lower, the opposing behavioral responses offset each other, leaving average holdings unchanged. By contrast, when the limit is set at a higher level, the anchoring effect becomes stronger while the negative reaction to the restriction becomes weaker. As a result, average holdings increase after the limit is introduced with the higher limit.

Finally, we find that introducing a reverse waterfall functionality both increases adoption of the limited means of payment and decreases the level of its holdings. This suggests that these kind of automated funding mechanisms can allow individuals to benefit from the payment advantages of CBDC without requiring them to hold large CBDC balances.

Overall, we provide the first evidence that combining holding limits with automatic funding mechanisms can support the use of CBDC as a means of payment while addressing concerns about potential financial stability risks.

1 Introduction

Central Bank Digital Currencies (CBDC) are digital forms of sovereign currency issued by the central bank. Several central banks are currently designing retail CBDC to complement physical cash by providing individuals with an additional state-backed means of payment ([Illes et al., 2025](#)). CBDC would bring central bank money into the digital age aiming to support financial inclusion, protect privacy, and make payments easier and more secure for all. They would complement banknotes and coins, giving people an additional choice about how to pay. However, preventing users from storing excessive amounts in CBDC is also important to avoid excessive outflows of deposits from banks, preserving financial stability. To address this concern, central banks such as the ECB, the Bank of England, the Bank of Canada or the People’s Bank of China are designing CBDC that would feature a “holding limit” which would limit, at any point in time, the amount of CBDC that individuals could hold in their digital wallet ([Panetta, 2022](#); [Demertzis and Mejino-López, 2024](#)).¹ In parallel, several CBDC projects are considering automatic funding mechanisms which would allow users to make payments in CBDC without maintaining large CBDC balances.

Motivated by this central feature of CBDC, this paper studies how imposing a holding limit on a means of payment affects consumers’ liquid wealth allocation. Introducing a holding limit has an obvious direct effect on individuals’ allocation decisions by preventing users from exceeding the limit. In addition to this mechanical effect, holding limits can have indirect behavioral effects reflecting a change in consumer attitudes toward the means of payment that can further affect holdings. The direction of these indirect effects is a priori not clear. On the one hand, users may perceive a means of payment associated with a holding limit as a less attractive solution, leading them to hold fewer funds in CBDC than what is directly implied by the mechanical impact. Indeed, a limit can have an aversive impact by reducing decision rights (e.g. [Bartling et al., 2014](#)). On the other hand, the holding limit can act as a reference or anchoring point when individuals choose how much to hold, potentially leading them to hold amounts close to the limit, whereas they might have held less otherwise (e.g. [Ariely et al., 2003](#); [Abeler et al., 2011](#)).² Given that these effects are behavioral and real-world data on CBDC holdings are unavailable due to the lack of a large-scale CBDC implementation, we use an

¹Beyond CBDC, holding limits have also been considered for stablecoins ([Bank of England, 2025](#)).

²[Furnham and Boo \(2011\)](#) provide a literature review showing that the anchoring effect is one of the most robust cognitive heuristics.

experimental approach to assess whether indirect effects occur and, if so, to identify the direction of their influence on holdings.

Despite the importance of understanding the impact of a holding limit on CBDC holdings, to date, there is no paper explicitly dedicated to this question. Incentivized experiments on CBDC have focused on different aspects of the introduction of a CBDC on individuals' portfolio allocations including the introduction of a new payment method (Arifovic et al., 2023), greater privacy compared with other digital payment instruments (Borgonovo et al., 2021; Magin et al., 2026), the possibility of bearing interest (Camera, 2024), and their digital nature relative to cash (Camera et al., 2016).³ However, they do not address the role of the holding limit.⁴ More closely related to our contribution, some studies use surveys, which include questions on holding limits but do not experimentally manipulate either the existence or the level of such limits. For example, van der Horst and van Gent (2025) conduct a survey experiment on digital euro and find that, on average, participants consider €1,297 to be a logical amount for a holding limit by directly asking for the amounts to participants. Bidder et al. (2024) develop a quantitative macroeconomic model calibrated using survey data and show that the introduction of a holding limit is a necessary condition for a CBDC to be welfare-improving. Even closer to our study, Georgarakos et al. (2025) estimate in a survey experiment the causal effect of holding limits ranging from €1000 to €120000 on the propensity to adopt the digital euro and the amount allocated to it compared with other liquid assets. They find that higher holding limits tend to increase amount allocated.

Our preregistered study contributes to the literature by causally assessing the overall impact of the introduction of a holding limit on individuals' portfolio allocation while disentangling its direct mechanical effect from its indirect behavioral effects. To achieve this objective, we employ an online incentivized experiment that exogenously varies both the presence and the level of a holding limit. Specifically, participants face an allocation decision between two means of payment, first without any holding limit, and subsequently with one means subject to a holding limit. The baseline (*No Limit*) condition allows us to elicit individual behavior in the absence of constraints, which can then be compared to the behavior under the imposition of a holding limit to identify causal effects. After the

³See Jiang (2020) for a comprehensive review of experiments on CBDC.

⁴A growing literature (Li, 2023; Lambert et al., 2024; Nocciola and Zamora-Pérez, 2024) also aims to quantify the potential CBDC demand, which is a key variable to determine the economic and financial stability implications of its introduction, using econometric techniques and counterfactual exercises.

allocation choice, participants use allocated tokens in trading activities that generate monetary payoffs. Our experimental design differentiates itself from previous survey-based experiments by incorporating real monetary incentives, thereby mitigating potential biases commonly found in survey studies (e.g., social desirability bias, hypothetical bias, etc.; [Camerer and Hogarth, 1999](#)).

In addition, we investigate how the presence of a reverse waterfall functionality affects individuals' responses to these limits. To the best of our knowledge, we are the first to study how individuals respond to a CBDC associated with a reverse waterfall (RW) functionality, a key feature designed to preserve CBDC usability while limiting holdings in, for example, the foreseen design of the digital euro ([ECB, 2024b](#)).⁵ This functionality enables users to draw on funds from a linked commercial bank deposit account automatically converting them into CBDC whenever the user's CBDC balance is insufficient to complete a payment. This functionality is designed to operate alongside holding limits, allowing policymakers to constrain CBDC holdings without restricting the use of CBDC as a means of payment. However, little is known empirically about how individuals would respond to such a feature or about its effect on CBDC holdings. To address this gap, our experimental design includes a final condition in which the reverse waterfall functionality is enabled in the presence of a holding limit.

Our subject pool consists of 761 individuals from the four most populous euro area countries—France, Germany, Italy, and Spain—, all recruited via the online research platform Prolific. Sampling potential future users of the digital euro across multiple countries enhances the external validity of our findings for the euro area.⁶

Our results highlight that holding limits can generate indirect behavioral effects, beyond their mechanical role of capping maximum holdings. We find evidence of two opposing mechanisms affecting the holdings of a substantial fraction of “unconstrained” individuals (i.e., those whose initial CBDC holdings were below the limit). About 37% of them either increase (“attraction effect”) or decrease (“repulsion effect”) their CBDC holdings once the limit is introduced and these effects cannot be attributed to the mechanical impact of the limit. The overall net change thus depends on the relative strength of each indirect effect, which appears to depend on the level at which the limit is set. Under the

⁵The term “reverse” is used to distinguish this mechanism from the “waterfall” functionality, which operates in the opposite direction: CBDC is automatically transferred to bank deposits when incoming transfers cause holdings to exceed the holding limit.

⁶The selection of these four countries reflects a trade-off between broad population coverage, as they account for more than half of the euro area's population, and practical constraints related to translating materials into multiple native languages and the depth of available participant pools on Prolific.

lower limit, attraction and repulsion offset each other, leaving the average holdings of the unconstrained individuals unaffected. Under the higher limit, the repulsion effect is attenuated while the attraction effect is strengthened, leading to a net increase in holdings of the limited means of payment among unconstrained participants. Strikingly, when the limit is relatively high, the indirect behavioral effect dominates the direct mechanical effect, resulting in higher average holdings of the limited means of payment in the whole sample.

Finally, we show that introducing a reverse waterfall functionality increases adoption while reducing average holdings. Thus, the waterfall can allow individuals to benefit from the payment advantages of CBDC without requiring them to hold large CBDC balances. Taken together, these results highlight the potential value of combining holding limits with automatic funding mechanisms to support CBDC use while containing CBDC holdings.

The remainder of this paper is organized as follows: [section 2](#) presents the experimental design, [section 3](#) reports the theoretical framework and hypotheses, [section 4](#) presents the results and [section 5](#) concludes.

2 Experimental Design

In our experiment, participants first allocate their tokens between two means of payment, then they face automated sellers with whom they aim to complete trades. One means of payment, bank-card, yields interests but is rejected by some sellers while the other one, CBDC, is universally accepted but non-remunerated.⁷ The experiment follows a 3×2 design varying the presence of a limit and its level.

2.1 Characteristics of the means of payment

The characteristics of the two payment methods draw inspiration from key features of bank-card and CBDC payments. However, they are not intended to replicate these payment methods in full detail, but to introduce stylized comparative advantages to capture their essential characteristics while maintaining a simplified structure that facilitates the understanding of the participants. Tokens allocated

⁷While neutral phrasing was used in the experiment presenting the two means of payment as payment A and payment B, we refer to them using the name of the real-world instruments that inspired them. Accordingly, the remunerated means is referred to as “bank-card” and the other one as “CBDC”.

to bank holdings generate a 7% interest on all tokens allocated to this payment method, while CBDC holdings are not remunerated. Thus, this reflects the opposition between a non-interest bearing CBDC, such as the one envisaged in the euro area (ECB, 2025), and remunerated bank deposits. Bank-card payments are only accepted by 90% of the sellers in the market, capturing the limited ability to make peer-to-peer (P2P) bank-card payments. By contrast, CBDC payments are accepted by all sellers reflecting the possibility to do P2P payments and legal tender status as envisaged, for example, by the digital-euro design.⁸ Furthermore, participants incur an entry cost of 0.5 tokens to allocate at least 1 token to their CBDC holdings, capturing the cost of transitioning to a new means of payment as captured by, for example, Arifovic et al. (2023) and Magin et al. (2026). Finally, there is no limit on the number of tokens that can be allocated to bank holdings, while the maximum number of tokens that can be allocated to CBDC holdings can be limited. These characteristics are summarized in Table 1.

Model parameters were inspired by real-world values observed in the euro area but were primarily chosen to ensure experimental salience and internal validity, given our focus on treatment comparisons rather than individual decisions. The assumed 10% share of P2P payments is consistent with the observed 6% share in the euro area in 2024 (ECB, 2024a). The 7% interest rate exceeds recent remuneration on household deposits (e.g. the average household deposit rate in 2024 of 1.2% according to MFI interest rate statistics).⁹ This higher rate reflects the need to account for the smaller scale of monetary amounts in the experiment relative to real life and to preserve strict monotonicity of interest-generated gains once converted into fiat currency.¹⁰

Table 1: Summary of the two payment methods’ characteristics.

	Card-payment	CBDC
Interest	Generates a 7% interest	Does not pay any interest
Fixed cost	No fixed cost	Fixed cost of 0.5 tokens
Availability	Sellers accept only 90% of the time	Sellers always accept
Limit	No limit	Limit depends on the treatment

Note: Interests are generated once after the allocation stage.

⁸The digital euro is expected to be legal tender meaning that it would be accepted throughout the euro area for all types of payments (peer-to-peer, point of sale, or e-commerce), hence implying a larger acceptance than card-payments (Cipollone, 2025).

⁹In an experiment on CBDC, Choi et al. (2026) assume that credit card payments yield a 5% discount rate, whereas CBDC payments yield none. The interest rate in our study can be interpreted analogously, effectively capturing the same dimension in this context.

¹⁰In our setup, a 1 percentage point of interest yields an additional gain of £0.002, implying a minimum interest rate of 5% to ensure monotonic gains after rounding to the penny.

2.2 Stages, treatments and conditions

The experiment is composed of three conditions and two treatments. Each condition consists of two stages: an allocation stage and a trading stage.

Allocation stage: Participants face an allocation decision in which they need to allocate their endowment of 10 tokens between the two payment methods.

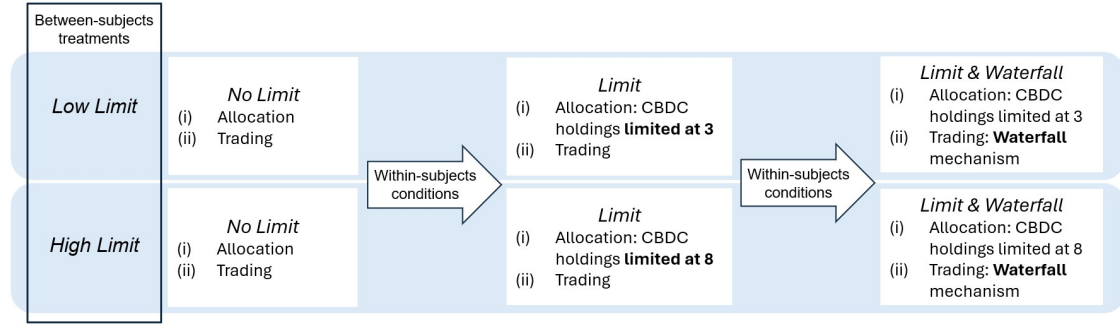
Trading stage: After their allocation decision, participants face 10 sellers with whom they can “trade” in 10 successive rounds. Participants are incentivized to realize successful trades.¹¹ Requirements needed for a trade to be successful are varied between conditions.

Condition variations: As mentioned earlier, each participant faces three conditions during the experiment (see Figure 1). In the *No Limit* condition, there is no limit on the number of tokens they can allocate to their bank-card holdings. In the *Limit* and *Limit & RW* conditions, the number of tokens that can be allocated to CBDC holdings is capped (the ceiling is varied between treatments). In addition, the *Limit & RW* condition differs from the other two as regards the outcome of a trade with a seller accepting only CBDC if the participant does not have tokens allocated to CBDC when meeting the seller. In the *No Limit* and *Limit*, this trade fails. By contrast, in the *Limit & RW* condition a token is automatically transferred from bank to CBDC holdings and is used to complete the trade, providing that the participant has allocated at least one token to CBDC holdings in the allocation phase. This latter constraint captures the need to have a CBDC account open to use the reverse waterfall mechanism.

Treatment variations: There are two treatments, which are varied randomly at the subject level. Each participant faces either a limit of 3 (*Low Limit*) or of 8 (*High Limit*) tokens in the *Limit* and *Limit & RW* conditions.

¹¹The interests generated from bank-card holdings and participants’ gains from trade are deposited on a separate account and cannot be used to trade. The fixed cost associated with CBDC holdings is deducted from participants’ gains from trade at the end of the trading stage.

Figure 1: Between-subjects treatments and within-subjects conditions



2.3 Experimental procedures

The experiment was conducted online using the platform Prolific in November 2025. A total of 761 individuals participated from the four most populated euro area countries, namely France, Germany, Italy, and Spain (190 participants per country except 191 for Spain; 374 in the *Low Limit* treatment and 387 in the *High Limit* treatment). Instructions were provided in the native language of each country (see English translation in Appendix E). The average age of the participants was 35 years old (sd = 11) and 49.6% were female.

One condition, among the 3 conditions, was randomly selected for the payment. Each successful trade yielded 10 points and points were converted at a rate of 50 points per £1.¹² The bonus payment was on average equal to £1.98. It adds to the hourly average payment of £2 (median time of 13 minutes) to constitute the total payoff per subject.

All participants faced the conditions in the same order: *No Limit*, *Limit* and *Limit & RW*. We chose to position the *No Limit* condition first in order to have a benchmark allocation where the potential implementation of a limit was unknown to the subject. Indeed, withdrawing the limit could have affected allocations in a *No Limit* condition presented second thus preventing a clean estimation of the impact of introducing a limit. Although this choice may introduce a potential order effect, the design leaves little room for such effects to arise in practice, since we provided no feedback to the subject until the payment screen was displayed at the very end of the session thus substantially restricts opportunities for learning or strategic adjustment across rounds (see Carlsson et al., 2024 for similar arguments). In order not to provide feedback during the trading stage, we asked participants to choose

¹²While all participants were from euro area countries, the experiment utilized Prolific's default currency.

which means of payment to use if the seller accepted both means of payment and they had both types of tokens available in conditions *No Limit* and *Limit*. This decision was then applied for all potential transactions.¹³ In the *Limit & RW*, this decision was actually irrelevant as participants either: i) allocated at least one token to CBDC and could complete all trades, ii) allocated all their tokens to card-payment and thus could only pay with card, if accepted by the seller. Therefore, participants did not have to make a choice in the trading stage of this condition.

At the end of the experiment, participants were asked to report their age, gender, native language as well as their self-reported risk preferences (Dohmen et al., 2011). We also elicited how confident they are in their ability to manage their finances using digital tools (such as online banking apps, digital wallets, or investment platforms) and their preferred payment methods when paying for goods or services in person (e.g., in stores) among cash, debit or credit card, a mobile payment app, or a digital wallet (the exact instructions are reported in Appendix E). Finally, participants could rate the clarity of the instructions and explain their allocation choices in each condition (open-ended non-mandatory questions).

3 Framework and hypotheses

This section formalizes how the introduction of a limit on CBDC holdings affects individuals' resource allocation between CBDC and bank-card holdings. We distinguish between a direct mechanical effect of the limit and two potential indirect behavioral effects: an attraction effect and a repulsion effect. Based on this framework, we derive testable hypotheses.

3.1 Setup

Let $x_C^l \in \{0, \dots, 10\}$ denote the number of tokens allocated to CBDC holdings by an individual in condition $C \in \{NL, L, L\&RW\}$ and treatment with a limit $l \in \{Low, High\}$, where *NL* denotes the *No Limit* condition, *L* the *Limit* condition, and *L&RW* the *Limit & RW* condition, while *Low* and

¹³Designing the experiment to include ten consecutive decisions per subject could have offered a more intuitive task. In such a setup, participants would have received information in each round about the seller's type and hence about the success of their trades. However, missed trades could have confounded subsequent allocation choices, while realizations of sellers' acceptance could have influenced their risk attitudes (Imas, 2016) or their expectations about future outcomes (Chen et al., 2016). Given these limitations, and as decisions in this stage are not of particular interest to us, we chose to favor a more constrained version of the decision set.

High denote the limits in the corresponding treatments. An individual is characterized as an adopter if $x_C^l \geq 1$. We distinguish two types of individuals based on their allocation choice in the *No Limit* condition. An individual is *unconstrained* by the limit if her *No Limit* allocation remains feasible once the limit is introduced, i.e. if $x_{NL}^l \leq l$. In contrast, an individual is *constrained* if $x_{NL}^l > l$. In the absence of indirect behavioral effects, standard revealed preference arguments imply that, on the one hand, unconstrained individuals should not adjust their allocation when a limit is introduced, i.e., $x_L^l = x_{NL}^l$ if $x_{NL}^l \leq l$. On the other hand, and also due to the monotonicity of the objective function, constrained individuals should allocate the maximum feasible amount to CBDC holdings, i.e., $x_L^l = l$ if $x_{NL}^l > l$.

3.2 Behavioral channels

We consider two indirect behavioral effects that may arise when a holding limit is introduced: a repulsion effect and an attraction effect. To avoid possible confounds from the direct effect of the limit, we focus our analysis on the allocation decisions of unconstrained individuals, for whom the limit implies no direct effect and thus no change in allocation ($x_L^l = x_{NL}^l$). Therefore, any deviation from this benchmark reveals the presence of an indirect behavioral effect.

The *repulsion effect* captures a reduced interest in the restricted means of payment. When a limit is introduced, individuals may perceive the CBDC as less attractive and reduce their allocation relative to the *No Limit* condition. This implies $x_L^l < x_{NL}^l$. In contrast, the *attraction effect* corresponds to an anchoring of the allocation decision to CBDC holdings towards the limit l , increasing CBDC holdings for unconstrained individuals. This implies $x_L^l > x_{NL}^l$.

Because individuals may be subject to both effects simultaneously, we interpret an overall decrease in CBDC holdings ($x_L^l < x_{NL}^l$) as evidence of a dominant repulsion effect, and an overall increase in CBDC holdings ($x_L^l > x_{NL}^l$) as evidence of a dominant attraction effect. When allocations remain unchanged, behavior is consistent with the benchmark model without indirect effects or with offsetting attraction and repulsion forces.¹⁴

¹⁴Note that our identification of attraction and repulsion effects is intentionally reduced-form. We do not attempt to structurally identify individual-specific behavioral parameters or to separately estimate the underlying attraction and repulsion functions. Instead, we classify individual responses based on observed changes in CBDC allocations when a holding limit is introduced.

Hypothesis 1 (Response to the limit with indirect effects) *For unconstrained individuals, the introduction of a holding limit changes CBDC allocations: $x_L^l - x_{NL}^l = 0$.*

A negative change indicates a dominant repulsion effect, a positive change indicates a dominant attraction effect, while no change is consistent both with offsetting attraction and repulsion forces or no indirect effects.

The magnitude of indirect behavioral effects is expected to depend on the level of the limit. A lower limit restricts decision rights more strongly and is therefore expected to generate stronger repulsion effects. By contrast, a higher limit provides a higher salient anchor and is expected to generate stronger attraction effects.

The definition of unconstrained individuals, $x_{NL}^l \leq l$, varies with the level of the limit. As a result, individuals with allocations such that $x_{NL}^l > Low$ but $x_{NL}^l \leq High$ are unconstrained under the High Limit but constrained under the Low limit. This mechanically changes the composition of the unconstrained group across limits and may induce selection bias when comparing changes in CBDC allocations. To cancel out this bias, we evaluate the magnitude of indirect effects—and consistently all between-limit comparisons—using decisions of ex-ante similar individuals under the High limit, namely those whose *No Limit* decisions would also leave them unconstrained under the Low limit ($x_{NL}^l \leq Low$).

Hypothesis 2 (Interaction with the limit level) *For ex-ante similar unconstrained individuals, the change in CBDC holdings induced by the introduction of a limit is increasing with the level of the limit l . Formally, for two limits $l \in \{Low, High\}$, and $High > Low$: $x_L^{High} - x_{NL}^{High} \geq x_L^{Low} - x_{NL}^{Low}$.*

3.3 Reverse waterfall mechanism

We now investigate associating a reverse waterfall mechanism to the limit affects CBDC holdings. To do so, we focus our analysis on comparisons between the *Limit* and the *Limit & RW* conditions. In the *Limit & RW* condition, participants still face a limit on the number of tokens they can allocate to CBDC holdings. However, if needed to complete the trade, one token is automatically transferred from bank-card to CBDC holdings, provided that the individual allocated at least one token to CBDC holdings in the allocation phase. This can have two distinct effects. First, allocating a single token

now completely removes the risk of failed transactions for the same cost as in the *Limit* condition, increasing the likelihood of adoption (“adoption effect”). Second, conditional on adoption, allocating more than one token no longer provides additional transactional benefits and entails an opportunity cost in terms of foregone interest, leading to a reduction in the number of tokens allocated to CBDC holdings (“intensive-margin effect”).

Hypothesis 3 (Response to the reverse waterfall mechanism) *Given both the adoption and intensity effects, the reverse waterfall mechanism induces individuals’ allocations to CBDC holdings to converge toward 1: $|x_{L\&RW}^l - 1| < |x_L^l - 1|$.*

4 Results

We first describe the level of CBDC holdings in the *No Limit* condition. Then, we assess the impact of introducing a limit by focusing on the difference between the *No Limit* and *Limit* conditions. Finally, we investigate the impact of introducing the reverse waterfall functionality by comparing the *Limit* and *Limit & RW* conditions. The analyses presented in this section are preregistered unless stated otherwise.¹⁵ Finally, we briefly comment on the impact of the demographics on our main variables.

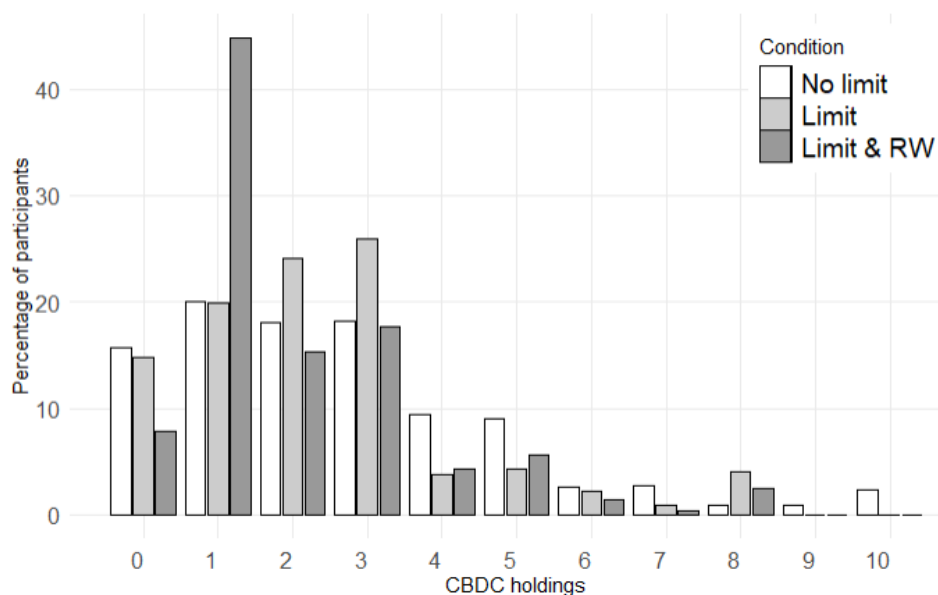
4.1 Descriptive statistics: CBDC holdings by condition

Figure 2 presents the distribution of tokens allocated to CBDC holdings in each condition. In the *No Limit* condition, the CBDC holdings of the participants are on average 2.68 tokens, which are close to the optimal holding of 3 tokens for a risk neutral individual suggesting that participants understood the incentives of the task.¹⁶ Mean holdings exhibit a reduction to 2.35 tokens in the *Limit* condition, and decline further to 2.05 in the *Limit & RW* condition.

¹⁵The preregistration is available at <https://osf.io/7wc3n>. Note that we preregistered the statistical analysis to test for the null hypotheses. All tests performed hereafter are two-sided tests.

¹⁶The optimal holdings of 3 tokens is obtained by maximizing expected payoffs, as detailed in Appendix A. This prediction remains unchanged under a prospect-theory utility specification using standard parameter values such as those estimated by Wu and Gonzalez (1996); Abdellaoui (2000); Abdellaoui et al. (2005) (value function curvature of 0.49 to 0.91 and weighting function parameter of 0.60 to 0.76).

Figure 2: Distribution of CBDC holdings in each condition



4.2 Overall effect of the limit

We start by assessing whether the responses of the unconstrained participants to the limit reveals the existence of indirect behavioral effects. Unconstrained participants represent 71.4% (N= 267) of the participants in the *Low Limit* treatment and 96.9% (N= 375) in the *High Limit* treatment.

Result 1 *When a limit is introduced, unconstrained participants hold more CBDC.*

Support for Result 1: We find a significant difference in the amount of tokens allocated to CBDC holdings by unconstrained participants between the *No Limit* and the *Limit* conditions, supporting [Hypothesis 1](#) (Wilcoxon signed-rank test, $p= 0.005$, [Figure 3a](#)). This suggests the presence of behavioral effects. While introducing a limit reduces CBDC holdings overall, this amount increases on average from the *No Limit* (mean: 2.04 tokens) to the *Limit* condition (mean: 2.23 tokens) for unconstrained individuals, suggesting a dominant attraction effect.¹⁷ Individual-level statistics confirm this finding. Although there is no mechanical reason to move, almost 40% of the participants do change their holdings. 21.0% increase by on average 2.09 tokens and 16% decrease by on average 1.50 tokens.¹⁸

¹⁷As presented in [Appendix D](#), we find support for this result as well as for [Result 2](#) and [Result 3](#) when focusing on each country individually.

¹⁸While unconstrained participants are those who cannot be mechanically affected by the introduction of the holding limit, another sample restriction could be relevant: excluding participants whose responses can only be one-sided. When further excluding participants who initially hold either 0 (i.e., who cannot be repulsed) or exactly the limit (i.e., who cannot be attracted), our result holds (Wilcoxon signed-rank test, $p= 0.001$). We find that 15.6% of them decrease their holdings by on average 1.48 tokens and 24.0% increase by on average 1.95 tokens.

To compare participants' responses between the different levels of the limit, the following analyses focus on ex-ante similar unconstrained participants. Ex-ante similar unconstrained participants represent 71.4% (N= 267) of the participants in the *Low Limit* treatment and 72.4% (N= 280) in the *High Limit* treatment. This comparison allows us to compare how the same ex-ante participants shift their allocations when facing different constraints.

Result 2 *For ex-ante similar unconstrained individuals, the change in CBDC holdings relative to the No Limit condition is larger in the High Limit than in the Low Limit treatment, where no change is observed.*

Support for Result 2: Among ex-ante similar participants, the increase in average CBDC holdings from the *No Limit* to the *Limit* condition is higher in the *High Limit* treatment compared to the *Low Limit* treatment (respectively +0.04 and +0.44 tokens, Mann-Whitney test, $p= 0.005$).¹⁹ In addition to this direct comparison between treatments, we assess whether [Result 1](#) is replicated for each treatment independently. The increase is statistically significant in the *High Limit* (+0.37, Wilcoxon signed-rank test, $p= 0.003$) but not in the *Low Limit* treatment (Wilcoxon signed-rank test, $p= 0.47$). This finding supports [Hypothesis 2](#) and further indicates that the increase in CBDC holdings is mainly driven by *High Limit* treatment.

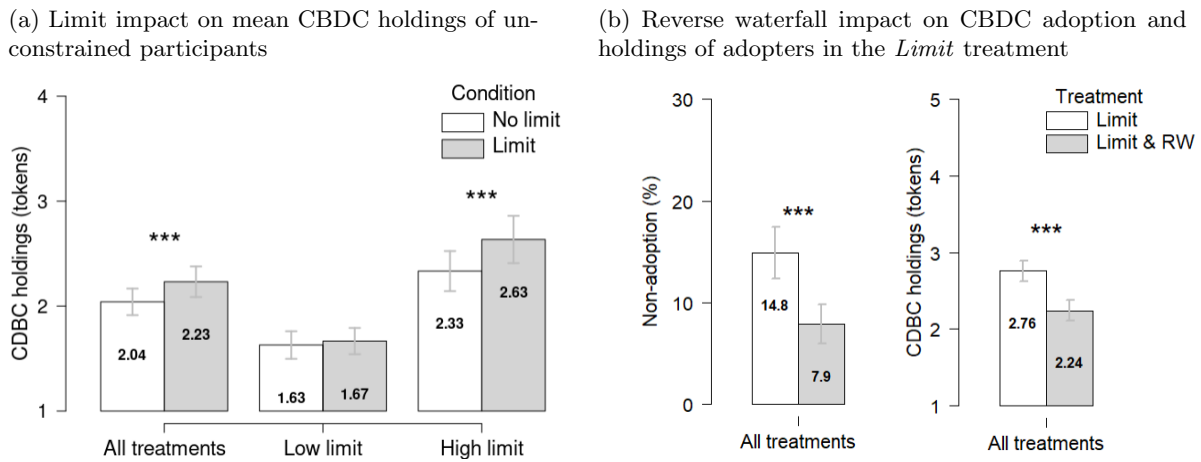
Overall impact: We have identified the existence of indirect effects that tend to increase CBDC holdings for unconstrained participants. We now turn to analyse the effect of the holding limit for all participants in order to evaluate how the direct effect of the limit compares to these indirect effects. Pooling both treatments, we find that the introduction of the limit decreases the mean CBDC holdings from 2.68 to 2.35 tokens (Wilcoxon signed-rank test, $p< 0.001$). This reduction is confirmed in the *Low Limit* treatment, where the mean holdings decrease from 2.80 to 1.93 tokens (Wilcoxon signed-rank test, $p< 0.001$). By contrast, in the *High Limit* treatment, the pattern is reversed, with the mean CBDC holdings increasing from 2.56 to 2.76 tokens (Wilcoxon signed-rank test, $p\text{-value} = 0.07$). Thus, we find evidence that, in this treatment, indirect effects can even dominate direct effects, leading to higher CBDC holdings following the imposition of a holding limit.

Blank-Limit Hypothetical for all participants: As mentioned earlier, imposing a limit directly

¹⁹These results are confirmed when controlling for between-subjects difference using a regression approach ([Table A-1](#)).

alters the amount of CBDC held by constrained participants, imposing us to focus on unconstrained participants. To provide a more comprehensive view that also includes constrained participants, we asked at the end of the *Limit* condition how many CBDC holdings they would have liked to have if no limit had been imposed, thus mechanically canceling out the direct effect of the limit. While responses to this un-incentivized debriefing question must be interpreted with caution, they offer a useful way to neutralize the direct effect of the constraint and focus on the indirect effect of the limit. On average, the hypothetical amount of CBDC holdings held in the *Limit* condition (mean: 2.93 tokens) is higher than the actual holdings in *No Limit* (mean: 2.67 tokens) (Wilcoxon signed-rank test, $p < 0.001$). Thus, it aligns well with [Result 1](#) for hypothetical amounts and the full sample. In addition, we find that the increase is driven by participants in the *High Limit* treatment (Wilcoxon signed-rank test, *Low Limit*: 2.80 to 2.82 tokens, $p = 0.51$, *High Limit*: 2.56 to 3.04 tokens, $p < 0.001$), providing evidence in line with [Result 2](#). These results suggest that simply being exposed to a limit (even when it is not enforced) influences allocations. Hence, it provides additional evidence that holding limits affect allocations not only through their direct constraining effect but also through indirect behavioral effects.

Figure 3: Limit and reverse waterfall impacts



Note: Panel (a) shows the average CBDC holdings of unconstrained participants (CBDC holdings in the *No Limit* treatment not exceeding the treatment limit) for the *No limit* and *Limit* conditions by treatment (all treatments: both *High Limit* and *Low Limit* treatments) (b) shows the adoption rate (left) and average CBDC holdings of participants holdings at least one CBDC token in the *Limit* treatment (right) for the *Limit* and *Limit & RW* conditions. 95% confidence intervals are represented by the vertical light gray lines. Stars derived by two-by-two comparisons of white and gray bars using Wilcoxon signed-rank tests for CBDC holdings and McNemar tests for adopters, * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

4.3 Attraction & repulsion effects of the limit

To understand the mechanisms behind [Result 2](#), we now explore the heterogeneity in individuals' responses to assess the existence and magnitude of the attraction and repulsion effects for each limit.²⁰

We first focus on the repulsion effect. We assess whether some participants are subject to repulsion and compare its magnitude between the *Low Limit* and *High Limit* treatment. We conduct separate analyses for constrained and ex-ante similar unconstrained participants as repulsion does not have the same consequences on both sub-samples. In the absence of indirect effect, constrained participants are expected to reduce their CBDC holdings in the *Limit* condition to exactly match the limit. Any further reduction can thus be interpreted as evidence of a repulsion effect. In the *Low Limit* treatment, CBDC holdings of constrained participants is lower than 3 tokens (Wilcoxon signed-rank test, $p = 0.003$, 71.0% of the participants hold 3 CBDC tokens), while in the *High Limit* treatment CBDC holdings are not statistically different from 8 tokens (Wilcoxon signed-rank test, $p = 0.35$, 83.3% of the participants are at 8 CBDC tokens). This provides some evidence of a higher repulsion effect of the lower limit among the constrained participants.

Next, we focus on the ex-ante similar unconstrained participants who can reduce their amount of CBDC held in the *Limit* condition compared to the *No Limit* condition (i.e. participants holding 1 to 3 CBDC tokens in the *No Limit* condition). We find that there are significantly fewer of these participants who reduce their CBDC holdings in the *High Limit* treatment than in the *Low Limit* treatment (respectively 12.9% vs 21.7%; proportion test, $p\text{-value} = 0.023$, [Figure 4a](#)). Among those reducing their holdings, the decrease is of comparable size in each treatment (-1.28 vs -1.30 tokens respectively in *Low Limit* treatment and in the *High Limit* treatment; t-test, $p = 0.89$; [Figure 4b](#)). Therefore, analyses on both constrained and unconstrained participants offer converging evidence of a higher repulsion effect under the *Low Limit* treatment.

We now compare the attraction effect between the *High Limit* and the *Low Limit* treatments by focusing on ex-ante similar unconstrained participants. These subjects can increase their CBDC holdings between the *No Limit* and the *Limit* condition. These are participants who allocate between 0 and 2 tokens to CBDC in the *No Limit* treatment).²¹ We find that 23.7% of these participants increase

²⁰Unlike the rest of our results, our analyses here were not pre-registered.

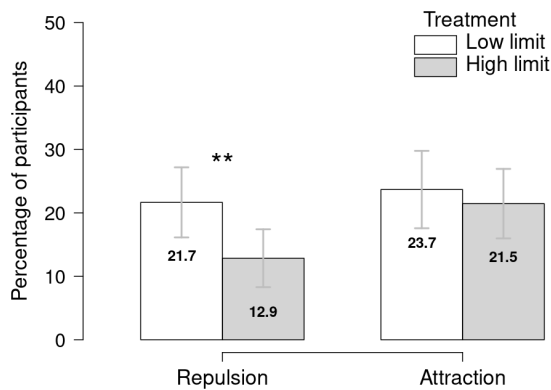
²¹We do not assess the presence of attraction on constrained participants as, by design, constrained participants cannot allocate more than the limit, which is the amount expected without indirect effect.

their CBDC holdings in the *Limit* compared to the *No Limit* condition in the *Low Limit* treatment and 21.5% in the *High Limit* treatment (Figure 4a). The difference between these proportions is not statistically significant (proportion test, $p=0.67$). It means that, at the extensive margin, the attraction effect is similar with the lower or the higher limit. However, among those who increase their CBDC holdings, the intensity of the increase is stronger with the higher limit compared to the lower limit (mean increase of 2.60 vs 1.56, t-test, $p\text{-value}=0.005$, Figure 4b). Thus, while the proportion of participants attracted is similar between treatments, they are attracted to a higher limit in the *High Limit* treatment, resulting in an overall stronger attraction effect.

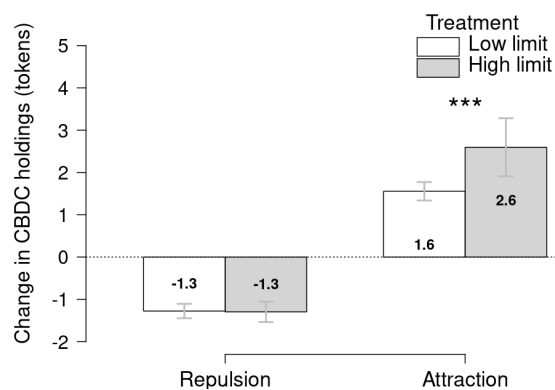
Therefore, we find that, with the lower limit, the attraction and repulsion effects cancel out. By contrast, with the higher limit, an equal proportion of participants is attracted, though to a higher value, while the proportion of repulsed participants declines. This leads the former effect to dominate the latter.

Figure 4: Attraction and repulsion

(a) Participants that either decrease (repulsion) or increase (attraction) the amount of CBDC held from the *No Limit* to the *Limit* condition.



(b) Average change in CBDC holding from the *No Limit* to the *Limit* treatment by repulsed and attracted participants.



Note: Panel (a) shows the percentage of ex-ante similar unconstrained participants that, if possible, either decrease (“repulsion”, left-hand side) or increase (“attraction”, right-hand side) their CBDC holding between the *No limit* and *Limit* conditions (b) shows the average change in CBDC holdings of ex-ante similar unconstrained participants that either decrease (“repulsion”, left-hand side) or increase (“attraction”, right-hand side) their CBDC holding between these conditions. 95% confidence intervals are represented by the vertical light gray lines. Stars derived by two-by-two comparisons of white and gray bars using proportion test for (a) and t-test for (b), * $p<0.1$; ** $p<0.05$; *** $p<0.01$.

4.4 Effect of the reverse waterfall mechanism

We now assess the impact of combining a limit with the reverse waterfall mechanism by comparing the *Limit* and *Limit & RW* conditions.

Result 3 *Allocations converge toward holding one CBDC token when a reverse waterfall mechanism is introduced.*

Support for Result 3: As can be seen in [Figure 2](#), the proportion of individuals holding exactly one CBDC token — the theoretically-optimal allocation with the reverse waterfall²² — rises from 19.8% to 44.8% in the *Limit & RW* compared to the *Limit* condition. In fact, one token becomes the most common allocation, although the average CBDC holdings remain statistically different from one (Mann-Whitney test, $p < 0.001$). Considering the entire sample, we find a convergence toward one in the *Limit & RW* condition compared to the *Limit* condition: the average absolute difference between CBDC holdings and one decreases from 1.65 to 1.21 tokens (Wilcoxon signed-rank test, $p < 0.001$), thus supporting [Hypothesis 3](#). This results both from i) an increase in CBDC adoption and ii) a reduction in CBDC holdings of adopters. Regarding the former, the proportion of non-adopters is approximately halved, from 14.8% in the *Limit* condition to 7.9% in the *Limit & RW* condition (McNemar test, $p < 0.001$, also presented in [Figure 3b](#)).²³ Turning to the intensive margin, average CBDC holdings of adopters decrease from 2.76 to 2.24 tokens (Wilcoxon signed-rank test, $p < 0.001$) as presented in [Figure 3b](#).²⁴ Overall, we observe a decrease in CBDC holdings from 2.35 to 2.05 tokens in the *Limit & RW* condition compared to the *Limit* conditions showing that the reduction of CBDC holdings among adopters dominates the increase in adoption (Wilcoxon signed-rank test, $p < 0.001$).

Focusing on the level of the limit, we find that our results hold when focusing either on the *High Limit* or the *Low Limit* treatment.²⁵ We further note that the reduction in mean CBDC holdings is of comparable size across treatments (-0.46 in *Low Limit* vs -0.57 in *High Limit*, Mann-Whitney test, $p = 0.50$), so that holdings remain higher in the *High Limit* treatment (2.75 vs 1.75 in the *Low Limit* treatment, Mann-Whitney test, $p < 0.001$). This means that while the reverse waterfall reinforces the downward effect of the limit on holdings, it does not make it redundant. It thus confirms that the reverse waterfall functionality is best to be used in combination with a holding limit.

²²See [Appendix A](#) for a formal proof.

²³By comparison, the adoption rate was not affected by the introduction of the limit (McNemar test, $p=0.4$; proportion of non-adopters in the *No Limit* treatment of 15.7%)

²⁴This finding is robust to comparing average holdings of adopters in the *Limit* and *Limit & RW* conditions.

²⁵In the *Low Limit* treatment, average CBDC holdings decrease from 2.21 to 1.75 for adopters in the *Limit* condition (Wilcoxon signed-rank test, $p < 0.001$) and from 1.92 to 1.62 for all participants (Wilcoxon signed-rank test, $p < 0.001$). Adoption increases from 87.2% to 91.2% (McNemar test, $p = 0.017$). In *High Limit* treatment, average holdings decrease from 3.32 to 2.75 for adopters in the *Limit* condition (Wilcoxon signed-rank test, $p < 0.001$) and from 2.76 to 2.48 for all participants (Wilcoxon signed-rank test, $p < 0.001$). Adoption increases from 83.2% to 93% (McNemar test, $p < 0.001$).

4.5 Additional analysis: individual characteristics

We explore individual determinants of i) the CBDC holdings, and ii) the change in CBDC holdings between the *No Limit* and *Limit* conditions.

Regarding the holdings, we regress the amount allocated to CBDC holdings on a set of control variables, first focusing only on demographics, then adding either risk aversion or variables related to payment savviness and, finally, by including all of these variables together (see [Table A-2](#) in Appendix). All regressions include country fixed-effects and heteroskedasticity-robust standard errors. We find that the more-risk averse individuals are, the more tokens they allocate to CBDC holdings. This is consistent with bank-card holdings having a higher risk of adverse outcomes (i.e., meeting with sellers who only accept CBDC). Male participants allocate, on average, about 0.5 less tokens to their CBDC holdings.

We use a similar approach to study the change in CBDC holdings between the *No Limit* and *Limit* conditions while adding as regressor CBDC holdings in the *No Limit* condition to control for initial allocations ([Table A-3](#) in Appendix). We find that individuals with a higher digital financial confidence adjusted less their holdings. We also find that preferring cash is also associated with less adjustment.

5 Discussion and Conclusion

We study how imposing a holding limit on a means of payment affects users' attitudes towards it. We find that the imposition of a holding limit has both a direct mechanical effect, capping the maximum holdings, and an indirect behavioral effect, which increases the holdings of the limited means of payment of the participants whose initial balances were below the limit.

We interpret this outcome as due to an attraction effect of the limit: the limit acts as an anchoring point that shifts allocations toward that value. Moreover, distinguishing between a lower and a higher limit, we find that this increase in holdings emerges only when the limit is higher.

The asymmetry of the results under the lower and a higher limit originates from the coexistence of two opposite indirect effects: the attraction effect described above, and a repulsion effect. The latter is driven by the restriction of decision rights, which renders the limited means of payment less attractive. Under the lower limit, these two effects offset each other, leaving the average allocation unchanged.

By contrast, a higher limit attenuates the repulsion effect while strengthening the attraction, thus shifting allocations toward higher values and generating a net positive indirect effect. Indeed, we find that, under the higher limit, the indirect effect dominates the direct effect of truncating the upper part of the decision set, resulting in higher average holdings of the limited means of payment, and thus a reversal of the expected effect of the limit. Finally, we provide the first empirical evidence that the introduction of a reverse waterfall functionality can successfully mitigate the behavioral responses to the holding limits, thereby increasing the adoption of the limited means of payment while containing holdings. These findings shed light on indirect behavioral effects that may arise from introducing a holding limit on a CBDC. Our experiment contrasts two means of payment: one that yields interest on holdings but has limited acceptance, and the other that is universally accepted but unremunerated and subject to a holding limit. In this respect, the design captures the core trade-off between remunerated bank deposits, allowing person-to-business (P2B) payments, and an unremunerated CBDC enabling both P2B and P2P transactions. These are expected features of, for example, the digital euro.

While caution is warranted when generalizing our results, our findings suggest that, when a limit is set sufficiently high, it may increase CBDC holdings among individuals who, in the absence of any constraint, would otherwise have held balances below that limit. By contrast, a sufficiently low holding limit tends, on average, to neutralize the behavioral indirect effects. As an exploratory exercise, we provide an order-of-magnitude interpretation of our lower and higher limit levels to enhance the practical relevance of our results. Using a back-of-the-envelope calculation, we match quantiles of CBDC holdings in the *No Limit* treatment with estimated average digital euro holdings from a euro area-wide survey (Garcia et al., 2026). We find that the implied lower and higher limits correspond approximately to €1000 and €5000, respectively. Indeed, in our data, 71% of participants hold no more than 3 tokens, which matches the estimated share of individuals holding less than €1000. Similarly, 96% hold no more than 8 tokens, aligning with the estimated share of individuals holding below €5000 in the estimated real-world distribution.²⁶ Under the higher holding limit of €5000, extrapolating our experimental estimates suggests an increase in CBDC holdings of about 13% for the individuals whose unbounded holdings would be below the limit.

²⁶This correspondence is consistent with Kim et al. (2025) that estimate that, in South Korea, less than 7% of individuals would be constrained with a holding limit equivalent to €3000. In our experiment, 6.5% of the participants are constrained by a limit of 6 tokens.

Our results further suggest that the reverse waterfall functionality, which allows individuals to benefit from the payment advantages of CBDC without necessarily holding any, is a particularly useful policy tool. Setting the level of the holding limit primarily reflects a trade-off between usability and financial stability: a higher limit enhances usability by allowing larger holdings, while a lower limit reduces the potential impact on the banking sector by limiting CBDC holdings and, therefore, possible deposit outflows from commercial banks. When used in combination with a holding limit, a reverse waterfall mechanism increases CBDC adoption while simultaneously reducing average holdings, thereby delivering gains on both sides of the usability–financial stability trade-off.

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APPENDIX

A Optimal decision

A.1 Baseline

As a benchmark, we compute the general form of the payoff function for a risk neutral individual then compute numerically the optimal for the set of parameters used in the design.

Parameters:

- Number of trading rounds: n
- Amount allocated to CBDC: x (with $x \in [0, n]$)
- Card remuneration: r .
- Probability that a seller only accepts CBDC: p
- CBDC fixed-cost: FC .

Let k be the number of P2P transactions. k follows a binomial distribution:

$$k \sim \text{Binomial}(n, p)$$

Card payments: We assume that individuals use card if card is available. Each unit invested in card raises a payoff of 1 if the amount on the card do not exceed the number of transaction where the card is allowed ($x \geq k$). In addition, it raises a remuneration of r .

$$\begin{aligned} P_{card}(x) &= (n - x)r + (n - x)\mathbb{P}(x \geq k) + (n - k)\mathbb{P}(x < k) \\ &= (n - x)r + (n - x) \sum_{i=0}^x \binom{n}{i} p^i (1 - p)^{n-i} + \sum_{i=x+1}^n (n - i) \binom{n}{i} p^i (1 - p)^{n-i} \end{aligned} \quad (1)$$

CBDC payments: each unit yields a payoff of 1 for sure. If an individual holds at least one unit of CBDC, they incur the fixed cost associated with using CBDC.

$$P_{CBDC}(x) = x - FC \mathbb{1}_{x \geq 0}$$

Thus the expected payoff is given by:

$$\begin{aligned} P(x) &= P_{card}(x) + P_{CBDC}(x) \\ &= (n-x)r + (n-x) \sum_{i=0}^x \binom{n}{i} p^i (1-p)^{n-i} + \\ &\quad \sum_{i=x+1}^n (n-i) \binom{n}{i} p^i (1-p)^{n-i} + x - FC \mathbb{1}_{x \geq 0} \end{aligned} \quad (2)$$

Computing the expected payoff of each decision with the parameters used in the experimental design ($n = 10$, $r = 7\%$, $p = 10\%$ and $FC = 0.5$ tokens), we find that the optimal answer is of $x = 3$ tokens.

A.2 Reverse waterfall functionality

We now compute the optimal strategy with the reverse waterfall functionality.

We first compute the optimal strategy provided that a digital euro account is open ($x > 0$). The payoff raised by tokens allocated to CBDC is unchanged. However, tokens allocated to card payment raise $1 + r$ units of payoff, irrespective of the number of P2P transactions.

$$\begin{aligned} P(x > 0) &= (n-x)(1+r) + x - FC \\ &= n(1+r) - xr - FC \end{aligned} \quad (3)$$

$\frac{\partial P(x > 0)}{\partial x} = -r < 0$. Thus $P(x > 0)$ is maximized for $x=1$.

We then compute the payoff raised by allocating 0 tokens to CBDC and compare it to the payoff for 1 CBDC.

If 0 token is allocated to CBDC, only $n - k$ trades are successful. Expected payoff is thus:

$$P(x = 0) = n(1 + r - p)$$

Comparing to the payoff for 1 CBDC:

$$\begin{aligned} P(x = 1) &> P(x = 0) \\ n(1 + r) - r - FC &> n(1 + r - p) \\ np - r &> FC \end{aligned} \tag{4}$$

It implies that the expected gain from allocating the first token to CBDC instead of card ($np - r$) should exceed the fixed cost associated. In our set up, $np - r - FC = 0.43$, thus $P(x = 1) > P(x = 0)$.

In conclusion, when the reverse waterfall functionality is available, expected payoffs are maximized by allocating one token to CBDC and the rest to bank-card payments.

B Additional Results

Table A-1: Impact of the level of the limit on the change in CBDC holdings from the No Limit to the Limit condition

	<i>Dependent variable:</i>			
	Change in CBDC holdings from No Limit to Limit condition			
	(1)	(2)	(3)	(4)
Treatment: High Limit	0.427*** (0.111)	0.412*** (0.111)	0.356*** (0.109)	0.322*** (0.109)
Risk aversion		−0.014 (0.025)		−0.017 (0.025)
Age		−0.008 (0.005)		−0.005 (0.005)
Gender: male		0.142 (0.111)		0.188* (0.112)
Gender: Other/no response		−0.480 (0.436)		−0.324 (0.412)
Decision Confidence		−0.047** (0.022)		−0.039* (0.022)
Preferred means of payment: cash		−0.186 (0.167)		−0.294* (0.167)
Preferred means of payment: mobile/digital		−0.038 (0.119)		−0.056 (0.122)
CBDC No limit condition	−0.233*** (0.033)	−0.233*** (0.034)	−0.265*** (0.050)	−0.271*** (0.051)
Constant	0.401*** (0.134)	0.905*** (0.284)	0.437*** (0.145)	0.789*** (0.304)
Sample	Unconstrained	Unconstrained	No Limit less 4	No Limit less 4
Country FE	Yes	Yes	Yes	Yes
Observations	642	640	547	545
R ²	0.079	0.096	0.073	0.093
Adjusted R ²	0.072	0.079	0.064	0.073
Residual Std. Error	1.352 (df = 636)	1.336 (df = 627)	1.271 (df = 541)	1.253 (df = 532)
F Statistic	10.920*** (df = 5; 636)	5.544*** (df = 12; 627)	8.509*** (df = 5; 541)	4.555*** (df = 12; 532)

Note: Panels are unconstrained participants for models (1) and (2), and ex-ante similar unconstrained participants for models (3) and (4). Heteroskedasticity-robust standard errors. Reference categories are: “Low Limit” for Treatment. “Debit or credit card” for Preferred means of payment, “Female” for Gender. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table A-2: Drivers of CBDC holdings in the *No Limit* condition

	<i>Dependent variable:</i>			
	CBDC holdings in No Limit condition			
	(1)	(2)	(3)	(4)
Risk aversion		0.065* (0.037)		0.068* (0.038)
Digital financial confidence			-0.023 (0.032)	-0.008 (0.034)
Preferred means of payment: cash			-0.392 (0.256)	-0.404 (0.256)
Preferred means of payment: mobile/digital			0.057 (0.184)	0.062 (0.184)
Age	0.006 (0.008)	0.006 (0.008)	0.008 (0.008)	0.007 (0.008)
Gender: male	-0.566*** (0.165)	-0.509*** (0.170)	-0.546*** (0.167)	-0.495*** (0.171)
Gender: Other/no response	0.056 (0.668)	-0.040 (0.669)	0.062 (0.671)	-0.011 (0.671)
Constant	2.745*** (0.319)	3.057*** (0.364)	2.879*** (0.389)	3.107*** (0.407)
Country FE	Yes	Yes	Yes	Yes
Observations	761	759	761	759
R ²	0.018	0.022	0.021	0.026
Adjusted R ²	0.010	0.013	0.010	0.013
Residual Std. Error	2.260 (df = 754)	2.257 (df = 751)	2.260 (df = 751)	2.257 (df = 748)
F Statistic	2.241** (df = 6; 754)	2.450** (df = 7; 751)	1.824* (df = 9; 751)	2.030** (df = 10; 748)

Note: heteroskedasticity-robust standard errors. Reference categories are: “Debit or credit card” for Preferred means of payment, “Female” for Gender. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table A-3: Drivers of change in CBDC holdings from the *No Limit* to the *Limit* condition

	<i>Dependent variable:</i>			
	Change in CBDC holdings from No Limit to Limit condition			
	(1)	(2)	(3)	(4)
Risk aversion		0.020 (0.025)		0.005 (0.026)
Digital financial confidence			-0.057*** (0.022)	-0.054** (0.023)
Preferred means of payment: cash			-0.343* (0.175)	-0.345** (0.174)
Preferred means of payment: mobile/digital			0.0002 (0.126)	-0.024 (0.125)
Age	-0.006 (0.005)	-0.005 (0.005)	-0.005 (0.005)	-0.004 (0.005)
Gender: male	0.004 (0.114)	0.004 (0.117)	0.042 (0.115)	0.024 (0.117)
Gender: Other/no response	-0.170 (0.458)	-0.198 (0.457)	-0.238 (0.458)	-0.243 (0.456)
CBDC No limit condition	-0.531*** (0.025)	-0.534*** (0.025)	-0.534*** (0.025)	-0.536*** (0.025)
Constant	1.283*** (0.229)	1.366*** (0.260)	1.685*** (0.275)	1.685*** (0.287)
Country FE	Yes	Yes	Yes	Yes
Observations	761	759	761	759
R ²	0.381	0.386	0.388	0.392
Adjusted R ²	0.375	0.379	0.380	0.383
Residual Std. Error	1.551 (df = 753)	1.540 (df = 750)	1.545 (df = 750)	1.535 (df = 747)
F Statistic	66.134*** (df = 7; 753)	58.816*** (df = 8; 750)	47.575*** (df = 10; 750)	43.816*** (df = 11; 747)

Note: heteroskedasticity-robust standard errors. Reference categories are: “Debit or credit card” for Preferred means of payment, “Female” for Gender. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

C Summary descriptive statistics and hypothesis testing

Table A-4: Mean CBDC allocation and CBDC adoption by treatment and condition

	Condition	No limit	Limit	Limit & RW
Mean CBDC allocation, all subjects	All	2.68	2.35	2.05
	Low Limit	2.8	1.93	1.62
	High Limit	2.56	2.76	2.48
Mean CBDC allocation, unconstrained subjects	All	2.04	2.23	1.97
	Low Limit	1.63	1.67	1.41
	High Limit	2.33	2.63	2.37
Percentage of adopters	All	84.2	85.2	92.1
	Low Limit	86.6	87.2	91.2
	High Limit	81.9	83.2	93

Note: "All" refer to all conditions aggregated.

Table A-5: Hypothesis testing, Wilcoxon tests

Test	Statistic	p-value	95% CI lower	95% CI upper
<i>Hypothesis 1</i>	17559	0.0046	2e-05	0.50003
<i>Hypothesis 2</i>	41676.5	0.00538	4e-05	2e-05
<i>Hypothesis 3</i>	67305	< 2.2e-16	0.99997	1.00008

D Robustness by country

In this section, we assess the robustness of our results by examining each country separately. We first discuss the direction and magnitude of the effects by country, and then turn to their statistical significance.

Regarding [Result 1](#), the difference in CBDC holdings between the *Limit* and *No Limit* conditions for unconstrained participants is, in every country, consistent with the direction reported in [Result 1](#). The magnitude of this difference ranges from 0.16 in Italy to 0.23 in Spain, compared with a sample-wide average of 0.19. Similarly, for [Result 2](#), the difference between the *High Limit* and *Low Limit* treatments in the change in CBDC holdings between the *Limit* and *No Limit* conditions of ex-ante similar unconstrained participants is positive in all countries, thereby confirming [Result 2](#) at the country level. This effect varies from 0.26 in France to 0.59 in Germany, relative to a sample average of 0.41. Finally, consistent with [Result 3](#), the difference in CBDC holdings between the *Limit & RW* and *Limit* conditions is negative in all countries. The magnitude of this effect ranges from -0.34 in Spain to -0.69 in France, compared with a sample average of -0.43.

Statistical significance at the country level is naturally affected by the fourfold reduction in sample size relative to the pooled analysis, which limits the power of country-specific tests. For [Result 1](#), p-values of Wilcoxon signed-rank test comparing holdings in the *No Limit* and *Limit* conditions are between 0.06 and 0.38. For [Result 2](#), p-values of Wilcoxon signed-rank test comparing change in holdings of unconstrained participants for the *High Limit* treatment and 0 are between 0.05 and 0.51. Finally for [Result 3](#), the Wilcoxon signed-rank tests comparing absolute deviation from 1 in *Limit* and *Limit & RW* conditions have p-value of at most 0.002. As an answer to the lack of power, we complement previous analysis with tests on whether country-level effects differ from the overall effect using Mann-Whitney tests. For [Result 1](#), we find no statistically significant differences at conventional significance levels (ES, p-value = 0.75; FR, p-value = 0.87; IT, p-value = 0.70 and DE, p-value = 0.59). The same holds for [Result 2](#) (ES, p-value = 0.96; FR, p-value = 0.45; IT, p-value = 0.99 and DE, p-value = 0.38) and [Result 3](#) (ES, p-value = 0.35; FR, p-value = 0.11; IT, p-value = 0.68 and DE, p-value = 0.81).

In conclusion, we find that country-level effect sizes are always in the same direction as the sample-

average effects. Using statistical tests that suffer from low power, we find that while effects are not always statistically significant at the country level, they are also never statistically different from the sample-average effects. We thus conclude that the evidence points toward the robustness of our results at the country level.

E Experimental Screens

General instructions

You will receive £2 of participation fee for completing the study.

In addition to the fixed participation fee, you can receive an additional bonus payment up to £2 based on your decisions in the study.

This study is composed of three parts.

At the end of the study, the computer program will randomly select one part to be the part that counts for your additional bonus payment.

Next

Instructions for Part 1 (1/5) Study Setup

You are a buyer who will:

- Allocate 10 tokens between two different payment methods.
- Choose which payment method to use in 10 consecutive trading rounds.

Your task is to complete as many trades as possible using your tokens.

For each successful trade, you earn 10 points.

Points are used to determine your bonus payment, converted at the rate: 50 points = £1.

Next

Instructions for Part 1 (2/5)

Allocation stage

You have 10 tokens. Recall that these tokens will be used in the trading stage to trade with 10 sellers.

In this stage, your task is to **allocate your 10 tokens between payment A and payment B**. Recall that these tokens will be used in the trading stage to trade with 10 sellers.

	Payment A	Payment B
Interests	Yields 0.7 point <i>per token</i> .	Yields no interest.
Fixed Cost	No cost.	<i>If at least one token allocated to payment B, costs 5 points.</i>
Availability	Accepted by 90% of the sellers.	Accepted by all sellers.

- Interests, and fixed cost are settled once after the allocation stage.

Next

Instructions for Part 1 (3/5)

Trading stage

In this stage, you will meet with 10 automated sellers in 10 consecutive rounds. For each round, your objective is to complete the trade to earn one point

You successfully complete the trade **only if you can use a payment method accepted by the seller**.

You cannot conclude the trade if the seller does not accept payment A and you have no tokens left in payment B.

Next

Instructions for Part 1 (4/5)

In summary, your bonus payment at the end of the experiment corresponds to the total number of points earned in the part randomly selected for payment, converted at the rate: **50 points = £1**.

Total number of points =

points earned by concluding successful trades (number of successful trades x 10 points)

+ Interest (number of tokens in payment A × 0.7 point)

- Cost (5 points, if at least one token in payment B)

Next

Instructions for Part 1 (5/5) Comprehension and Practice

Before you start Part 1, you will have to answer **a comprehension questionnaire**.

In addition, to familiarize yourself with the interface, you will have the opportunity to **practice** an allocation decision and a shorter trading stage (with 4 rounds instead of 10).

You will not receive any bonus payment for the practice.

Press 'Next' to start the comprehension questionnaire.

Next

Comprehension Questionnaire

Please answer the following question on the instructions.

The 'Next' button will appear once you have answered all questions correctly.

Q1. For each successful trade, you earn 10 points.

☐ True ☐ False

Q2. Which statement(s) is/are true regarding Payment A?

- ☐ Payment A yields 7% interest on all tokens allocated to payment A before the trading stage.
- ☐ Payment A requires a one time cost of 5 points to allocate token to it.
- ☐ Payment A is accepted by 90% of the sellers.

Q3. Which statement(s) is/are true regarding Payment B?

- ☐ Payment B yields 7% interest on all tokens allocated to payment B before the trading stage.
- ☐ Payment B requires a one time cost of 5 points to allocate token to it.
- ☐ Payment B is accepted by 90% of the sellers.

Q4. Which situation can prevent a trade from succeeding?

- ☐ The seller does not accept payment A and you have no tokens left in payment B.
- ☐ The seller does not accept payment B and you have no tokens left in payment A.

Q5. Any token left at the end of the 10 rounds will be converted in points and part of my bonus payment.

☐ True ☐ False

REMIND ME OF THE INSTRUCTIONS

CHECK MY ANSWERS

Practice: Allocation Stage

Your task is to allocate your 4 tokens between Payment A and Payment B:

	Payment A	Payment B
Interests	Yields 0.7 point <i>per token</i> .	Yields no interest.
Fixed Cost	No cost.	<i>If at least one token allocated to payment B, costs 5 points.</i>
Availability	Accepted by 90% of the sellers.	Accepted by all sellers.

Indicate how you would like to allocate your tokens between payment A and B:

(select the amount you want to allocate to payment B and allocation to payment A will automatically adjust)

Payment A:	Payment B:

Validate

Practice: Trading Stage

In each of the 4 trading rounds, you will trade with a seller which can either accept both payment A and B, or only payment B.

- If the seller accepts both payment methods and you have tokens in both payment A and B at this round: you need to choose which payment method you want to use.

You make this decision once and it will be implemented for all 4 rounds in this part.

Note that your choice may affect your ability to complete trades.

- For example, if you use your Payment B tokens when A can be used, you might not have any Payment B token left when you encounter a seller who only accepts Payment B.
- If the seller accepts only payment B: you will use Payment B if you still have tokens left in B. Otherwise, you cannot complete the trade.
- If the seller accepts both payment A and B and you have tokens allocated to only payment A or only payment B at this round: you use this type of token to complete the trade.

Indicate the payment method you would like to use when the seller accepts both Payment A and B and you have tokens left in both Payment A and B:

Payment A	Payment B
☐	☐

Validate

[More details on the choice of the payment method](#)

Practice: Feedback

Here is some feedback about the practice you just completed:

Allocation stage:

- You allocated 4 tokens to payment A and 0 tokens to payment B.
- You earned 2.8 points in interests from your tokens allocated to payment A.

Trading stage:

- You indicated that you prefer to use payment B if the seller accepts both payment A and B and you have tokens left in both payment A and B.
- You met a seller who accepted only payment B in round 4. Recall that while there is a 10% chance to meet a seller who accepts only payment B, it can more or less frequent.
- You completed 3 trades and earned 3 points from these trades.

The table below summarizes what happened in each of the trading rounds:

Round	The seller accepts	Your choice of payment method	Tokens in payment A	Tokens in payment B	Successful trade?
1	payment A and B	payment B	4	0	Yes, with payment A (you did not have any token left in payment B)
2	payment A and B	payment B	3	0	Yes, with payment A (you did not have any token left in payment B)
3	payment A and B	payment B	2	0	Yes, with payment A (you did not have any token left in payment B)
4	payment B	payment B	1	0	No

Note that you will only receive feedback for the part that has been selected for payment at the end of the study.

Press 'Next' when you are ready to start Part 1.

Next

Part 1: Allocation Stage

Your task is to allocate your 10 tokens between Payment A and Payment B:

	Payment A	Payment B
Interests	Yields 0.7 point <i>per token</i> .	Yields no interest.
Fixed Cost	No cost.	<i>If at least one token allocated to payment B, costs 5 points.</i>
Availability	Accepted by 90% of the sellers.	Accepted by all sellers.

Indicate how you would like to allocate your tokens between payment A and B:

(select the amount you want to allocate to payment B and allocation to payment A will automatically adjust)

Payment A:	Payment B:
	----- ▼

Validate

Part 1: Trading Stage

In each of the 10 trading rounds, you will trade with a seller which can either accept both payment A and B, or only payment B.

- **If the seller accepts both payment methods and you have tokens in both payment A and B at this round: you need to choose which payment method you want to use.**

You make this decision once and it will be implemented for all 10 rounds in this part.

Note that your choice may affect your ability to complete trades.

- For example, if you use your Payment B tokens when A can be used, you might not have any Payment B token left when you encounter a seller who only accepts Payment B.
- If the seller accepts only payment B: you will use Payment B if you still have tokens left in B. Otherwise, you cannot complete the trade.
- If the seller accepts both payment A and B and you have tokens allocated to only payment A or only payment B at this round: you use this type of token to complete the trade.

Indicate the payment method you would like to use when the seller accepts both Payment A and B and you have tokens left in both Payment A and B:

Payment A	Payment B
☐	☐

Validate

[More details on the choice of the payment method](#)

Part 1: End

You completed Part 1.

Note that you will only receive feedback for the part that has been selected for payment at the end of the study.

Press 'Next' when you are ready to start Part 2.

Next

Instructions for Part 2 (1/1)

In Part 2, you will face exactly the same decisions as in Part 1.

However, now there is a limit on the number of tokens that you can allocate to payment B:

You can allocate at most 8 tokens to payment B.

The characteristics of the two payment methods are described again in the table below:

	Payment A	Payment B
Interests	Yields 0.7 point <i>per token</i> .	Yields no interest.
Fixed Cost	No cost.	<i>If at least one token allocated to payment B, costs 5 points.</i>
Availability	Accepted by 90% of the sellers.	Accepted by all sellers.
Limit	No limit.	Limit of 8 tokens.

Next

Part 2: Comprehension Questionnaire

Please answer the following question on the instructions.

The 'Next' button will appear once you have answered the question correctly.

The maximum number of tokens I can allocate to Payment B is:

REMIND ME OF THE INSTRUCTIONS

CHECK MY ANSWERS

Part 2: Allocation Stage

Your task is to allocate your 10 tokens between Payment A and Payment B:

	Payment A	Payment B
Interests	Yields 0.7 point <i>per token</i> .	Yields no interest.
Fixed Cost	No cost.	<i>If at least one token allocated to payment B, costs 5 points.</i>
Availability	Accepted by 90% of the sellers.	Accepted by all sellers.
Limit	No limit.	Limit of 8 tokens.

Indicate how you would like to allocate your tokens between payment A and B:

(select the amount you want to allocate to payment B and allocation to payment A will automatically adjust)

Payment A:	Payment B:
	----- ▼

Validate

Part 2: Trading Stage

In each of the 10 trading rounds, you will trade with a seller which can either accept both payment A and B, or only payment B.

- **If the seller accepts both payment methods and you have tokens in both payment A and B at this round: you need to choose which payment method you want to use.**

You make this decision once and it will be implemented for all 10 rounds in this part.

Note that your choice may affect your ability to complete trades.

- For example, if you use your Payment B tokens when A can be used, you might not have any Payment B token left when you encounter a seller who only accepts Payment B.
- If the seller accepts only payment B: you will use Payment B if you still have tokens left in B. Otherwise, you cannot complete the trade.
- If the seller accepts both payment A and B and you have tokens allocated to only payment A or only payment B at this round: you use this type of token to complete the trade.

Indicate the payment method you would like to use when the seller accepts both Payment A and B and you have tokens left in both Payment A and B:

Payment A	Payment B
☐	☐

Validate

[More details on the choice of the payment method](#)

Part 2: End

You completed Part 2.

Note that you will only receive feedback for the part that has been selected for payment at the end of the study.

Before starting Part 3, please answer the following question about your decision in part 2:

In part 2, how much would you have chosen to allocate to payment method B if there were no limit?

Next

Instructions for Part 3 (1/1)

Now payment B will be automatically refilled when needed, as long as you allocated at least one token to payment B in the allocation stage.

This means that if a seller accepts only payment B and you do not have any token left in payment B, then a token from payment A will be automatically reallocated to payment B to allow you to complete the trade.

The characteristics of the two payment methods are described again in the table below:

	Payment A	Payment B
Interests	Yields 0.7 point <i>per token</i> .	Yields no interest.
Fixed Cost	No cost.	<i>If at least one token allocated to payment B, costs 5 points.</i>
Availability	Accepted by 90% of the sellers.	Accepted by all sellers.
Limit	No limit.	Limit of 8 tokens.
Automatic Refill	Cannot be automatically refilled.	Can be automatically refilled as long as you allocated at least one token to payment B.

Next

Comprehension Questionnaire

Please answer the following question on the instructions.

The 'Next' button will appear once you have answered the question correctly.

If you face a seller that accepts only payment B and you have no token B left:

- ☐ You cannot complete the trade if you did not allocate at least one token to Payment B.
- ☐ You complete the trade only if you have allocated at least one token to payment B (one token A is automatically reallocated to payment B to allow you to complete the trade).
- ☐ You complete the trade even if you do not have allocated any token to payment B (one token A is automatically reallocated to payment B to allow you to complete the trade).

REMIND ME OF THE INSTRUCTIONS

CHECK MY ANSWERS

Part 3: Allocation Stage

Your task is to allocate your 10 tokens between Payment A and Payment B:

	Payment A	Payment B
Interests	Yields 0.7 point <i>per token</i> .	Yields no interest.
Fixed Cost	No cost.	<i>If at least one token allocated to payment B, costs 5 points.</i>
Availability	Accepted by 90% of the sellers.	Accepted by all sellers.
Limit	No limit.	Limit of 8 tokens.
Waterfall	Cannot be automatically refilled.	Can be automatically refilled as long as you allocated at least one token to Payment B.

Indicate how you would like to allocate your tokens between the two means of payment:

(select the amount you want to allocate to payment B and allocation to payment A will automatically adjust)

Payment A:	Payment B:

Validate

Part 3: Trading Stage

In each of the 10 trading rounds, you will trade with a seller which can either accept both payment A and B, or only payment B.

You do not have any decision to make in this stage as choosing which payment method to use when the seller accepts both payment methods does not affect whether a trade will be successful or not.

This is because payment B will be automatically refilled when needed, as long as you allocated at least one token to payment B in the allocation stage.

Consequently, there are two cases:

- If you allocated **at least one token to B**: you are certain to complete the 10 trades, irrespective of whether you choose Payment A or B.
- If you **did not allocate any token to B**: you will pay with Payment A when it is accepted, irrespective of whether you choose Payment A or B.

Next

Part 3: End

You completed Part 3.

Note that you will only receive feedback for the part that has been selected for payment at the end of the study.

Before starting the final questionnaire, please answer the following question about your decision in part 3:

In part 3, how much would you have chosen to allocate to payment method B if there were no limit?

Next

Questionnaire (1/3)

How would you describe the clarity of the instructions?

- ☐ Extremely unclear
 - ☐ Somewhat unclear
 - ☐ Somewhat clear
 - ☐ Extremely clear
-

In part 1, you chose to allocate 2 tokens to Payment A and 8 tokens to Payment B.

Briefly explain your choice (optional):



In part 2, you chose to allocate 3 tokens to Payment A and 7 tokens to Payment B.

Briefly explain your choice (optional):



In part 3, you chose to allocate 4 tokens to Payment A and 6 tokens to Payment B.

Briefly explain your choice (optional):



Next

Questionnaire (2/3)

On a scale from 0 to 10, how confident are you in your ability to manage your finances using digital tools (such as online banking apps, digital wallets, or investment platforms)?

Which of the following payment methods do you prefer using when paying for goods or services in person (e.g. in stores):

- ☐ Cash
- ☐ Debit or credit card (not including via a digital wallet or app)
- ☐ A mobile payment app or digital wallet on your smartphone, smartwatch, or another mobile device

Are you a person who is generally willing to take risks, or do you try to avoid taking risks on a scale from 0 (completely unwilling to take risks) to 10 (completely willing to take risks)?

Next

Questionnaire (3/3)

How old are you?

Which gender do you identify with?

- ☐ Male ☐ Female ☐ Other ☐ Prefer not to say

Is English the language you speak most at home?

- ☐ No ☐ Yes

Retype the word **SALSIFY** in the box below:

Is there anything you would like to say about the study? (optional)

Next

End of the study

You have completed the study. Thank you for your participation!

You earned a total of £4.0 for this study.

You will receive your fixed payment of £2 on your Prolific account shortly.

In addition, you earned 99.90 points = £2.0 from your decision in the study.

Part 2 was randomly selected for payment.

- You allocated 7 tokens to Payment A and 3 tokens to Payment B.
- You completed 10 trades successfully.
- You earned 4.9 points in interests from your tokens allocated to payment A.
- You paid 5 points to use Payment B.

You will receive your bonus payment on your Prolific account within 3 days.

Study submission

Open the submission link by clicking on the link below or copy-pasting the URL into your internet browser to submit your participation and receive your payment: <https://app.prolific.co/submissions/complete?cc=C15YTIXH>

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