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The offline digital euro and holding limits: a user-centred approach

An online experiment among Dutch consumers

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Executive summary

The national central banks of the Eurosystem are investigating the possibility of issuing a retail central bank digital currency (CBDC) – the digital euro – alongside cash. The digital euro would be subject to a holding limit, meaning there would be limit to the amount of digital euro an individual can hold. A holding limit would prevent excessive outflows from the banking system, which could endanger financial stability. For the offline digital euro, a specific consideration for setting a holding limit is also to mitigate anti-money laundering/countering the financing of terrorism (AML/CFT) risks. At the same time, given that the digital euro is a public means of payment, it is important that everyone is able to use it. A holding limit should therefore not hamper the usability of the digital euro. In existing research on CBDC, this user-centred perspective to holding limits has received limited attention. The added value of this study lies in taking a user-centred perspective.

De Nederlandsche Bank conducted an experiment on offline digital euro holding limits among 2,000 adult participants in the Netherlands. The aim of this study was to gain insight into

- The intention to pay with the offline digital euro, both in situations where it is certain and uncertain that people can pay by debit card;
- The relationship between the digital euro and cash, and;
- What amount of digital euro Dutch people would consider holding and how this relates to a possible holding limit.

The focus of this study was on the **offline** digital euro, rather than all foreseen functionalities of the digital euro. This focus was chosen to avoid overcomplicating matters for participants and because offline has a distinct added-value feature compared to the current debit card payment infrastructure in the Netherlands.

Based on this research, we see a solid potential for the offline digital euro in the Netherlands from the user's perspective. Two third of the participants are willing to use the offline digital euro. One third does not make use of this means of payment, mainly because they do not see the added value compared to current means of payment or due to unfamiliarity.

Participants use the offline digital euro as if it were cash. Participants prefer to carry less than 500 euro of the offline digital euro, except for those who have a relatively high monthly budget and face a situation in which it is not certain they can pay by debit card. A maximum of €1,298 for the (offline) digital euro (5% trimmed mean) is considered a logical limit among those who use the digital euro. If participants face uncertainty about being able to pay by debit card, they carry more offline digital euro and cash with them, with the digital euro being preferred over cash. Considering that the offline digital euro would also work without an internet or network connection, this means that the offline digital euro can serve as a backup for the regular payment infrastructure. Moreover, this research shows that the currently often-cited total holding limit of €3,000 would not constrain usability of the offline digital euro from the perspective of users in the Netherlands.

62% of participants who use the digital euro, want to use an automatic top-up function. Results show that the offline digital euro should be a card as well as an app: 42% prefer the digital euro in the form of a card; 33% would like a mobile app, and 26% have no preference. For 68% of all participants, privacy is not a reason in deciding whether to make more use or less use of the digital euro.

This paper contributes to the existing body of research by taking a user-centred approach to studying CBDC holding limits.

The conclusions in this study may be useful to policymakers and central banks in further shaping the characteristics of the digital euro. The exact features of the digital euro will ultimately be decided by European politicians.

1 Introduction

The national central banks of the Eurosystem are investigating the possibility of issuing a retail central bank digital currency (CBDC) – the digital euro – alongside cash. The digital euro, designed for both online and offline use, would serve as a versatile means of payment. It would facilitate person-to-person payments, e-commerce and transactions in physical stores. The offline functionality would allow for payments without an internet- or network connection, making it useful in areas with limited internet or network coverage or during power outages. To utilize this feature, users must pre-fund their digital euro account via the internet or designated ATMs. Transactions are directly validated by two offline devices (e.g., mobile phones or payment cards) owned by the parties involved, ensuring privacy of the transaction by avoiding central systems or third-party intermediaries.

To protect financial stability and the transmission of monetary policy, the digital euro will be subject to a holding limit per individual. The holding limit will contribute to making the digital euro primarily a means of payment and not for saving, as the digital euro legislative proposal by the European Commission (2023) envisions it. For the offline digital euro, a specific consideration for setting a holding limit is also to mitigate AML/CFT risks. The holding limit has not been calibrated yet and will be set closer to potential issuance. Businesses and merchants will have a zero holding limit. This means they would not be able to hold digital euros, while not constraining their ability to accept digital euro payments.

As more than two thirds of central banks around the world are considering a retail CBDC that is subject to holding limits (Di Iorio, Kosse & Mattei, 2024), CBDC holding limits have also been a topic

of debate in the academic literature. Most existing literature on the topic of holding limits focuses on holding limits as a mitigating factor for financial stability and banking system risks of a CBDC. For example, Bindseil (2020) and Bindseil and Panetta (2020) suggest that the maximum bank deposit outflow could be contained by imposing a €3,000 digital euro holding limit per person. Meller and Soons (2023) also suggest that a €3,000 holding limit would be successful in containing the impact on banks' funding structures and liquidity risks. More recently, Bidder, Jackson & Rottner's (2024) structural macroeconomic model shows that a holding limit retains the gains of increased stability from a CBDC arising from 'slow' disintermediation of the banking system, while limiting the downsides of 'fast' disintermediation of the banking system.

1.1 User perspective

While the main consideration for CBDC holding limits may be financial stability from a central bank and systemic point of view, an important question is how future users will interact with and experience holding limits. There should be a balance between the goal of financial stability and an optimal user experience. Ultimately, the payment instrument must also be attractive to use. With this paper, we contribute to the existing body of research by taking a different, user-centred approach to studying CBDC holding limits. After all, according to De Heij (2017), the user is crucial because the user determines the adoption and success of new payment methods. To better understand the usage and interaction with holding limits, we took a user behavioural approach. In the academic discussion on CBDC holding limits, user behaviour has so far only received limited attention in the literature. One of these studies was done by ECB colleagues Lambert, Larkou, Pancaro, Pellicani and Sintonen in 2024. They find that 80% of individuals would not be constrained by a €3,000 limit as their estimated digital euro holdings are less than

this amount, even at the upper range of their estimates. Also, Bidder, Jackson and Rottner (2024) used a survey to study households' portfolio choice in a digital euro and a non-digital euro scenario and in a banking distress scenario.
In our study, we used a survey with an experimental element in which a real-life situation is described. We added this experimental element to it, because the risk of surveys is that they may not give a complete picture of how consumers actually react. We were mainly interested in gauging how Dutch consumers behave at two moments of choice: 1) when allocating their monthly budget to the digital euro, cash or their debit card account and 2) when paying for an item at a point of sale.

Consumers do not have any experience with the digital euro yet, so it is unknown whether they will adopt this payment method. Van der Cruijsen and Van der Horst (2019) show that it is difficult for consumers to change payment behaviour, which depends mainly on payment intentions and habits. It is known that a gap can exist between payment preferences and actual payment behaviour (Van der Cruijsen, Hernandez & Jonker, 2017). Furthermore, actual control over payments is also relevant for payment behaviour. Van der Cruijsen & Van der Horst (2019) suggest that in order to steer payment behaviour, it is necessary to improve control by limiting the failures and increasing the degree of acceptance.

In this study we want to explore Dutch consumers' attitudes and behaviours regarding the offline digital euro, with an emphasis on holding limits. We chose to limit ourselves to examining only the offline digital euro and not the online version. Reasons for this are that we expect that Dutch consumers, because of the well-functioning and digitalised payment infrastructure in the Netherlands, will in practice not see that much of a difference

between the use of a card or app for an online digital euro payment and their bank debit card (or app). The offline digital euro, on the other hand, would have a distinct added-value feature in the Dutch payments landscape. An additional consideration is that we did not want to make the experiment too complicated for participants, with accompanying lengthy explanations, as participants are not yet familiar with the new payment option.

1.2 Digital form of cash

As the offline digital euro has many characteristics in common with cash, like privacy and serving as a back-up in case of disruptions in the payment chain, it is useful to examine whether participants would use the offline digital euro in a similar way as cash.

As many functions of the offline digital euro are comparable to those of cash, we first want to explore whether participants use the digital euro in the same way as cash, which could have implications for the size of the holding limit. The use of cash in Dutch point-of-sale (POS) payments has declined significantly in the past decade. The share of cash in payments has been close to 20% since 2020 (De Nederlandsche Bank and the Dutch Payments Association, 2024). Bank cards/mobile payments are used in around 4 of every 5 transactions. Even with a diminishing cash usage, most Dutch citizens carry cash with them. In a telephone survey conducted by DNB, most respondents reported that they usually carry banknotes (79%) and/or coins (81%) (DNB, 2023). The median amount that people from the Netherlands have in their wallet at the start of the day is €35 (ECB, 2024), which is less than the median amount for the euro zone (€59). A study by Knab among 1,000 Dutch clients is in line with this. Although on average, their clients have €89.24 in their wallets, such an average gives a distorted picture due to some (very) high amounts. The median amount of €50 is more representative:

half of those surveyed have more and the other half less than €50 in their wallets. In this study, we hypothesised that participants would not take more than €500 offline digital euro with them.

Second, we want to examine if the usage of the offline digital euro differs for situations of uncertainty compared to certainty. Cash usage tends to be higher in situations where the payment infrastructure in a country is uncertain or unreliable. When people are unsure if they can use electronic payment methods like debit or credit cards, they often prefer to carry cash as a backup. This behaviour is observed in various contexts, such as small businesses, markets, and events where electronic payment options might not always be available or functional. One of the purposes of the offline digital euro is to increase the resilience of the payments landscape by ensuring that transactions can still be completed even if electronic systems fail or are not accepted. It could therefore be a back-up means of payment in addition to cash.

A third objective is to investigate whether a precautionary pattern holds true for both cash and the digital euro. Lippi & Moracci (2024) highlight that both transaction size and availability of cash significantly influence payment choices. Their data reveals that people tend to use cards when the purchase amount is nearly equal to their cash on hand, for otherwise they would be left with minimal residual cash. This behaviour indicates a precautionary motive to maintain a cash buffer.

In the ECB study on payment attitudes by consumers (ECB, 2024), participants in the euro zone were asked what they consider to be the three most important advantages of cash compared with card payments. The most mentioned advantage (by 41% of participants) was that cash is anonymous and protects privacy. Furthermore, 60%

of the population in the euro zone expressed concerns about privacy when making digital payments or engaging in other banking activities. This concern was less prevalent in the Netherlands. One third (32%) of the Dutch participants answered 'yes' to the question if they were concerned about their privacy when making digital payments. The level of privacy when making payments with the offline digital euro will be comparable to that of cash. **Therefore, it is interesting to know whether privacy would be a reason for participants to make more or even less use of the offline digital euro.**

1.3 Limitations

As previously mentioned, this study only focuses on the offline variant of the digital euro. The reasons are:

- Because of the well-functioning and digitalised payment infrastructure in the Netherlands, the Dutch average consumer will likely not see that much of a difference between the use of a card or app for an online digital euro compared to their bank debit card (or app). The offline digital euro offers the most distinct added-value feature for the Dutch payments landscape.
- Including the online variant would mean that, prior to the experiment, we would have to explain the differences between the online and offline form, which would make it more difficult for participants to understand. This is particularly relevant as the digital euro is a new means of payment for participants.
- Including the online variant would overly complicate the setup of the experiment.

Furthermore, in our introduction to the participants – see Section 2 – we described differences between the various means of payment. However, we did not consider all allocation costs and usage costs. This is because it would overly complicate the explanation to participants and not all of these costs are known.

Finally, this study was conducted among Dutch adults and thus cannot readily be extended to the entire euro area.

1.4 Contents

The remainder of this Occasional Study is structured as follows. Section 2 describes the setup of the experiment. Section 3 presents the results and in Section 4 we discuss our findings and the implications of our results. In the Annex we provide the instructions, tasks and questionnaire that were given to participants.

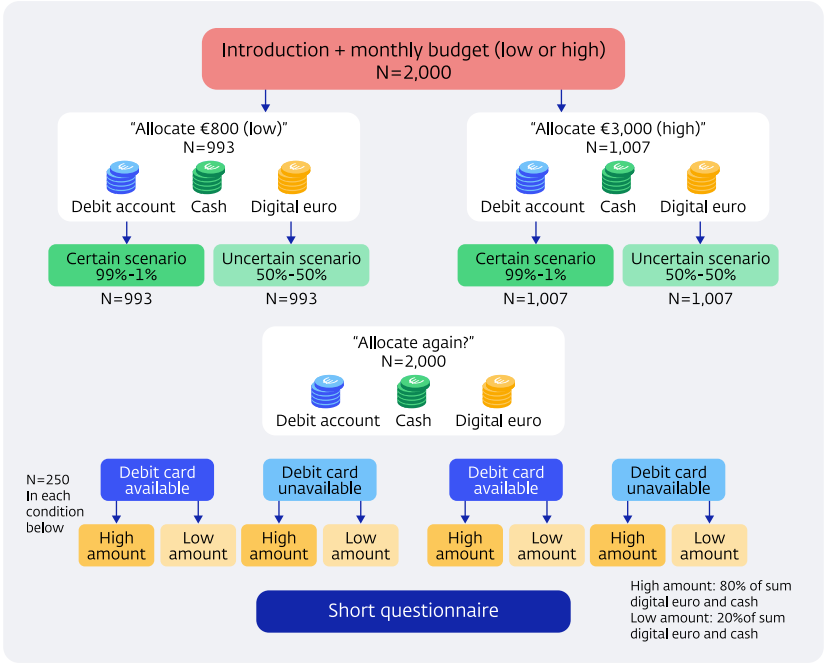
2 Method

We discussed our ideas on the design of this study with Professor Christian Olivers, PhD, of Vrije Universiteit Amsterdam, and subsequently had research agency Flycatcher carry out the survey. Flycatcher started in 2000 as a spin-off from Maastricht University, and cooperates with many Dutch universities.

Participants form a sample consisting of Dutch people aged 18 and over from the Flycatcher panel. This panel is ISO certified and consists of more than 10,000 adults who have voluntarily and actively agreed to participate in online surveys via 'double-active-opt-in'. Panel members receive a small, pre-determined number of reward points for each fully completed questionnaire, which can be redeemed for a gift voucher. In addition, panel members automatically play in the Flycatcher Quarterly Lottery, in which participation in surveys, among other things, determines the chances of winning in the lottery. We aimed for a net total of 2,000 participants, which we achieved. Overall, there was a balanced distribution across gender, age, education and province in our participants pool that is representative of the Dutch adult population.

The task for participants consisted of two parts: an online experiment and a short questionnaire afterwards. Figure 1 shows the schematic setup of the experiment; the Annex shows the exact instructions that were given to the participants.

Figure 1 Schematic overview of the research design



In the experiment, the participants were randomly divided into two groups of equal size with either a high or a low monthly budget (i.e. €3,000 or €800). These two amounts roughly correspond with a net modal income and a social benefit. The participants were told that in the coming month, they would have to make several payments in shops with this budget. Next, they were asked to allocate their monthly budget between their payment account at their bank, their digital euro account and cash. From their payment account, they could transfer money to their digital euro account and/or withdraw cash from an ATM. Before allocating the monthly budget, the characteristics of the three payment methods were shown to participants.

We then distinguished between two scenarios. The first concerned a situation in which the chances of participants being able to pay by debit card in-shop were 99 out of 100 times (the 'certain scenario'). The second was a situation in which the chances of being able to pay by debit card in-shop was only 50 out of 100 times (the 'uncertain scenario'). All participants were exposed to both scenarios, but in a different order. After their first allocation, half of participants were first faced with the certain scenario followed by the uncertain scenario, and the other half were first faced with the uncertain scenario followed by the certain scenario. This was done in order to minimise question order bias. For each scenario, participants were asked whether they would like to reallocate their budget and if so, how they would reallocate it. In total, all participants went through three allocation questions.

Next, participants were told to make a purchase in a physical shop, and asked to indicate how they would like to pay. Optionally, participants could pay with multiple payment methods for one purchase. This would mainly occur when a single means of payment is insufficient to settle the amount of the purchase. The participant had to indicate what amount the participant would like to pay by which means of payment, as long as the total amount paid added up to the purchase price that was shown. We decided to allow for the option of using multiple means of payment for a single purchase, as this situation is conceivable in real life and because the potential distribution across different means could provide interesting information about the way in which the offline digital euro will be used in the future.

Both the participants that were in the high monthly budget and in the low monthly budget group were further randomly divided into four groups, because a purchase could occur in four different

situations. The purchase was either a high or a low amount (which we defined as 80% (high) or 20% (low) of the sum of offline digital euro and cash balance from the most recent allocation by the respective participant) and the purchase was either done in a scenario in which the debit card is an available means of payment or in which the debit card is unavailable (e.g. because of a temporary technical disruption). This results in a setup of 8 groups consisting of 250 participants each.

At the end of the experiment, participants were asked to fill in a short questionnaire with a few questions, such as about the role of privacy, preference for an app or a card for the digital euro, potential usage of the option to link a digital euro account to a bank account for automatic top-up of the account, etc.

Data collection took place from August to September 2024.
On average, participants took 9.57 minutes to fill in the form.
Participants' feedback shows that the level of interest in the subject, duration and clarity of the tasks and questionnaire were rated similarly to the average of other research carried out by Flycatcher.

3 Results

This section presents the results of this research. This section is divided into three main sub-sections: 1) budget allocation and potential maximum holding of digital euro, 2) payment behaviour and 3) additional results.

3.1 Budget allocation and potential maximum holding of digital euro

A majority of participants (67%) chose to use the digital euro. The number of times participants chose to allocate some of their budget to the digital euro is summarised in Table 1. This shows that a majority of participants (67%) allocated part of their monthly budget to the digital euro in at least one of their budget allocations.

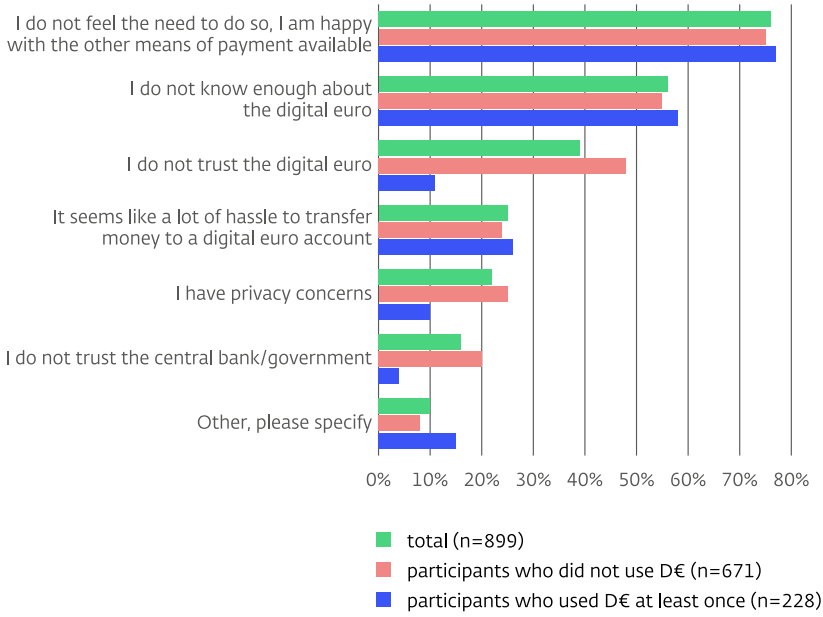
Table 1 Number of times participants chose to allocate money to the digital euro in their budget allocations

	Absolute	Relative
3 times	1,093	54.7%
2 times	63	3.2%
1 time	173	8.7%
0 times	671	33.6%
Total	**2,000**	**100%**

The flip side is that 34% of participants did not choose to allocate money to the digital euro account in any of the budget allocation scenarios. In the questionnaire, we asked the participants who did not allocate any money to the digital euro in at least one of their budget allocations for their reason(s) for non-usage. The responses to this question are summarised in Figure 2. From the responses,

it emerges that the main reasons in order of importance are 1) not feeling the need to use the digital euro because existing means of payment function well enough, 2) unfamiliarity with the digital euro and 3) lack of trust in the digital euro. If we split the responses between participants who did not use the digital euro at all and participants who used the digital euro at least once, it can be seen that trust and privacy concerns are more prevalent in the group of participants who did not use the digital euro at all.

Figure 2 Participants' responses to why they did not use the digital euro



As hypothesised, participants generally allocated less than €500 to their offline digital euro account, but there are exceptions, especially in the group of participants who received a relatively high monthly budget. Results show that on average people with a low and high monthly budget allocated significantly less than €500 euro to the digital euro in their first allocation, €125.98 and €462.12 respectively (Table 2). When looking at the results for budget allocation after participants are faced with the scenarios of payment certainty or payment uncertainty (Table 3 and Table 4), a similar picture emerges. Participants with a low monthly budget allocated significantly less than €500 to the digital euro account in both scenarios of payment certainty (€119.87) and payment uncertainty (€207.03). The same holds for participants with a high monthly budget who are faced with a scenario of payment certainty (€433.36). There is only one group of participants who on average allocated significantly more than €500 to the digital euro account. This concerns those with a high monthly budget who are faced with a scenario of payment uncertainty (€738.49).

Table 2 First budget allocation (all participants)

	low budget (€800)			high budget (€3,000)		
	chosen	average amount	relative amount	chosen	average amount	relative amount
debit account	94%	€542.91	68%	97%	€2,155.83	72%
digital euro	53%	€125.98	16%	60%	€462.12	15%
cash	72%	€131.12	16%	74%	€382.05	13%

Table 3 Budget allocation after being faced with payment certainty (all participants)

	low budget (€800)		high budget (€3,000)	
	average amount	relative amount	average amount	relative amount
debit account	€551.11	69%	€2,189.10	73%
digital euro	€119.87	15%	€433.36	14%
cash	€129.02	16%	€377.54	13%

Table 4 Budget allocation after being faced with payment uncertainty (all participants)

	low budget (€800)		high budget (€3,000)	
	average amount	relative amount	average amount	relative amount
debit account	€411.19	51%	€1,747.96	58%
digital euro	€207.03	26%	€738.49	25%
cash	€181.78	23%	€513.56	17%

In Table 5, Table 6 and Table 7 below, the average amounts are recalculated based only on participants who chose to allocate their budget to the respective payment option. Looking only at participants who chose to allocate some of their budget to the digital euro, we see that participants with a low monthly budget allocated less than €500 to the digital euro in all scenarios, whereas participants with a high monthly budget allocated more than €500 to the digital euro irrespective of payment certainty or uncertainty.

Table 5 First budget allocation (average amounts based only on participants who chose the respective payment option)

	low budget (€800)			high budget (€3,000)		
	chosen	average amount	relative amount	chosen	average amount	relative amount
debit account	94%	€576.58	58%	97%	€2,231.16	64%
digital euro	53%	€238.73	24%	60%	€765.38	22%
cash	72%	€182.10	18%	74%	€512.97	15%

Table 6 Budget allocation after being faced with payment certainty (average amounts based only on participants who chose the respective payment option)

	low budget (€800)		high budget (€3,000)	
	average amount	relative amount	average amount	relative amount
debit account	€628.58	68%	€2,419.66	72%
digital euro	€172.53	19%	€593.77	18%
cash	€114.75	13%	€340.20	10%

Table 7 Budget allocation after being faced with payment uncertainty (average amounts based only on participants who chose the respective payment option)

	low budget (€800)		high budget (€3,000)	
	average amount	relative amount	average amount	relative amount
debit account	€393.00	41%	€1,611.73	46%
digital euro	€350.18	36%	€1,276.39	36%
cash	€223.48	23%	€652.90	18%

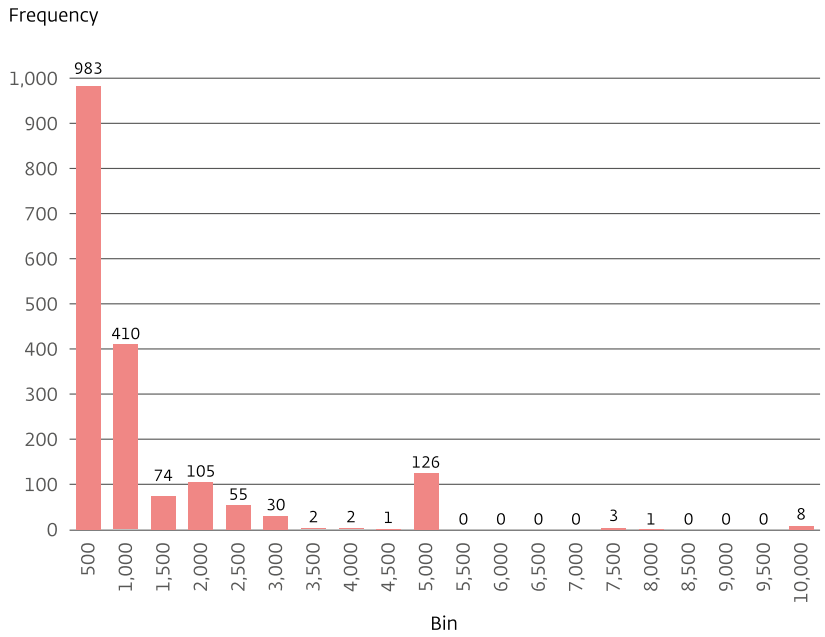
If there were a maximum imposed on digital euro holdings, participants who used the digital euro indicated that they find €1,298 (5% trimmed mean) a logical maximum for the digital euro based on their daily lives. After participants were faced with the budget allocation and purchase scenarios, we asked them 'if there were a maximum to the amount of digital euro you can hold, what would you find a logical maximum based on your daily life?'. The mean of all responses was €5,543 (see Table 8). Given that there were some extreme responses on the lower side (lowest: €1) and upper side (€999,999, as the input was limited to six digits), we chose to remove 5% of the most extreme responses on the lower and upper side to give a more balanced average representation. The 5% trimmed mean of all participants' responses was €1,092. Participants who did not use the digital euro on average found a lower maximum (€695, 5% trimmed mean) more logical based on their daily lives than participants who used the digital euro at least once (€1,298, 5% trimmed mean). It can be noticed that the non-trimmed mean is higher for participants who did not use the digital euro than for participants who used the digital euro at least once. This is because from the four participants in total who indicated that they would find €999,999 a logical maximum, three participants did not use the digital euro, pushing the non-trimmed mean for digital euro non-users upwards.

Figure 3 shows the distribution of responses of the 5% trimmed dataset. While most answers can be grouped into the two lower bins from €1 to €500 and €500 to €1000, it can be noticed that a logical maximum of €5,000 was also relatively frequently preferred (126 times). For 12% of all participants the often-cited limit of €3,000 would not be sufficient.

Table 8 Mean and trimmed mean for logical maximum digital euro based on peoples' daily lives, split out across participants who did not use the digital euro and participants who used the digital euro at least once

	All participants		D€ non-users		D€ users at least once	
	Mean	5% trimmed mean	Mean	5% trimmed mean	Mean	5% trimmed mean
Logical maximum amount	€ 5,543	€ 1,092	€ 8,121	€ 695	€ 4,241	€ 1,298

Figure 3 Histogram of respondents' indicated logical maximum, based on a 5% trimmed dataset



In the absence of information on payment certainty or when assured of payment certainty, participants with a low monthly budget allocated comparable amounts to the digital euro and cash, while participants with a high monthly budget allocated a higher amount to the digital euro than to cash in these situations. Table 2 shows that in the first allocation (no information given on payment certainty/uncertainty) the average amount of digital euro participants allocated to the digital euro (€125.98) is comparable to the average amount that participants allocated to cash (€131.12) for those with a low monthly budget. These amounts are not significantly different. By contrast, participants with a high monthly budget allocated a significantly higher amount to the digital euro (€462.12) than to cash (€382.05) in their first allocation. When assured of payment certainty, there was also no significant difference in the amount that participants with a low monthly budget allocate to digital euro (€119.87) and cash (€129.02) (Table 3). Again, for participants with a high monthly budget, we did see a significantly higher allocation to the digital euro (€433.36) than to cash (€377.54) in the case of payment certainty.

When faced with uncertainty, participants allocated more money to the digital euro and to cash, and relatively more to the digital euro than to cash. From Table 3 and Table 4, it can be seen that participants with a low and a high monthly budget allocated a higher amount to the digital euro in a scenario of payment certainty compared to a scenario of payment uncertainty. These differences are statistically significant. The same applies to cash allocation. Participants (both with a low and a high monthly budget) allocated a significantly higher amount to cash in a scenario of payment uncertainty compared to a scenario of payment certainty. For allocation to the debit account, we see the opposite effect. Participants allocated significantly less budget to their debit account

when faced with payment uncertainty. When moving from a scenario of payment certainty to payment uncertainty, results show that participants take relatively more digital euro than cash with them (Table 9). This holds for participants with a low as well as a high monthly budget.

Table 9 Relative increase in budget allocation when moving from a scenario of payment certainty to a scenario of payment uncertainty

	low budget (€800)		high budget (€3,000)	
	digital euro	cash	digital euro	cash
percentual increase	73%	41%	70%	36%

The allocation results are robust against question order bias effects, which were pre-emptively minimised by randomising the order in which participants were faced with either payment certainty or payment uncertainty. Since all participants got two re-allocation questions, one faced with payment certainty and one faced with payment uncertainty, we were aware that question order bias effects may occur. We tested whether there was a question order bias. For the payment certainty scenario, we see little question order bias (Table 10). In this scenario, the only question order bias effect detected was that participants with a low monthly budget allocated significantly more money to their debit account when they were faced with the payment certainty scenario first, compared to the group of participants who were faced with the payment certainty scenario for their second re-allocation. In the payment uncertainty scenario, more question order bias effects were detected (Table 11). In this scenario, participants who were given the payment

uncertainty scenario first allocated significantly more money to their debit account and allocated significantly less money to the digital euro than those who were given the payment uncertainty scenario for their second re-allocation. This applies to participants with both a low and a high monthly budget. We minimised these question order bias effects pre-emptively by randomising the order in which participants were faced with either payment certainty or payment uncertainty.

Table 10 Average budget re-allocation based on the payment certainty scenario

	low budget (€800)		high budget (€3,000)	
	99% first	99% second	99% first	99% second
debit account	€567.59	€533.92	€2,191.91	€2,186.46
digital euro	€112.85	€127.19	€447.92	€419.67
cash	€119.56	€138.89	€360.17	€393.86

Table 11 Average budget re-allocation based on the payment uncertainty scenario

	low budget (€800)		high budget (€3,000)	
	50% first	50% second	50% first	50% second
debit account	€427.80	€395.28	€1,862.19	€1,626.48
digital euro	€192.27	€221.18	€656.17	€826.03
cash	€179.94	€183.54	€481.65	€547.49

3.2 Payment behaviour

Depending on the amount that participants allocated to the three means of payment and the amount that participants had to pay in store, there were participants who were either left with only one choice for means of payment or had to select all three means of payment to be able to make the payment. These participants de facto did not have a choice between different means of payment (a forced choice). This concerns 12% of participants. In interpreting the results on payment behaviour, it is therefore important to realise that 12% of participants did not have a choice between the different means of payment.

Overall, results show that as long as people carry enough of all three means of payment (offline digital euro, cash, debit card), people mostly pay by debit card. This is in line with expectations in view of the well-functioning debit card payments infrastructure in the Netherlands. Table 12 shows that four fifths of participants choose to pay by debit card as long as they have a choice between a minimum of two means of payment. This corresponds to the current situation in the Netherlands where 4 out of 5 transactions are paid by card (De Nederlandsche Bank and Dutch Payments Association, 2024). Furthermore, 8% of participants choose to pay with a combination of debit card and digital euro, 6% choose to pay by debit card and cash, and 4% choose to pay by debit card, digital euro and cash.

Table 12 Participants' choice for different means of payment[1]

	Absolute	Relative
debit card	530	60%
digital euro	109	12%
cash	69	8%
debit card and digital euro	71	8%
debit card and cash	54	6%
digital euro and cash	10	1%
debit card, digital euro and cash	36	4%
Total	**879**	**100%**

A higher percentage of participants choose to pay by digital euro when faced with a high payment amount compared to a low payment amount, defying a 'precautionary motive' for digital euro. The percentage of participants choosing to pay with the digital euro was significantly higher when participants were faced with a high payment amount as opposed to a low payment amount. This holds for participants with both a low and a high monthly budget (see Table 13 and Table 14). This also applies to cash, but to a lesser extent. When participants are faced with a high payment amount compared to a low payment amount, the relative amount of digital euro participants pay is also higher. This effect is opposite from our expectation. In line with a 'precautionary motive' often seen for cash, we expected that a higher percentage of participants would choose to pay by digital euro when faced with a low payment amount, so as to retain some digital euro for unforeseen future expenses or circumstances.

1 Based on the scenario in which the debit card is available and in which respondents had a choice between a minimum of two payment means.

Table 13 Payment choices for participants with a low monthly budget, in case the debit card is an available payment option

	low monthly budget (€800) high payment amount			low monthly budget (€800) low payment amount		
	chosen	average amount	relative amount	chosen	average amount	relative amount
debit card	79%	€127.59	43%	64%	€31.93	44%
digital euro	32%	€89.90	30%	19%	€20.48	28%
cash	27%	€81.71	27%	23%	€20.43	28%

Table 14 Payment choices for participants with a high monthly budget, in case the debit card is an available payment option

	high monthly budget (€3,000) high payment amount			high monthly budget (€3,000) low payment amount		
	chosen	average amount	relative amount	chosen	average amount	relative amount
debit card	83%	€449.96	47%	71%	€138.52	56%
digital euro	32%	€350.56	36%	22%	€58.91	24%
cash	21%	€162.46	17%	18%	€49.21	20%

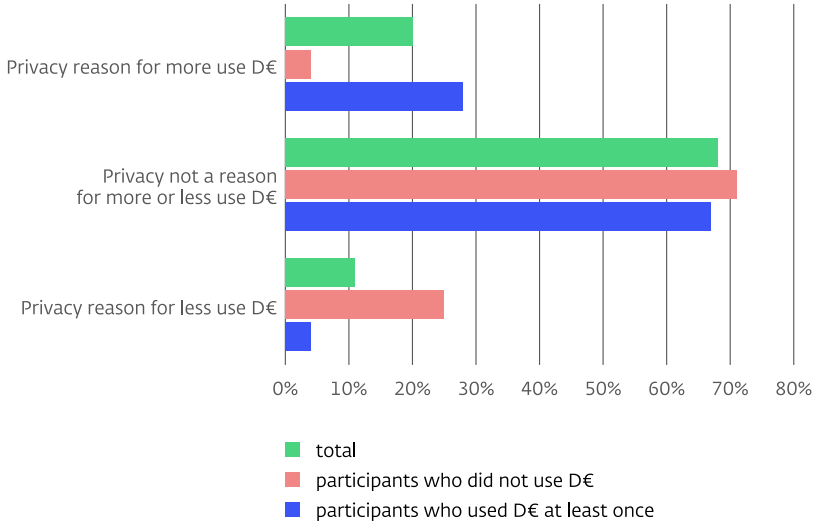
3.3 Results from additional questions

The questionnaire that participants filled in after the tasks gave us some additional insights into potential usage of the offline digital euro. The key findings are presented below.

For 68% of all participants, privacy is not a factor in deciding whether to use the digital euro more or less often. This applies to participants who used the digital euro in this experiment, as well as

to those who did not use the digital euro (see Figure 4). Slightly more than a quarter of users (28%) expect that privacy would be a factor to make more use of the digital euro. On the other hand, a quarter of non-users (25%) mention privacy as a reason to make less use of the digital euro.

Figure 4 Participants' responses to whether privacy would be a reason for using the digital euro



Regarding the form of the digital euro, most participants (42%) prefer a physical card, followed by a mobile app (33%) and no preference (26%). This can be seen from Figure 5. Preferences differ across age. Table 15 shows that participants in age categories below 65 years prefer an app on their mobile phone significantly more often than participants above 65 years of age.

Figure 5 Participants' form preferences for the digital euro

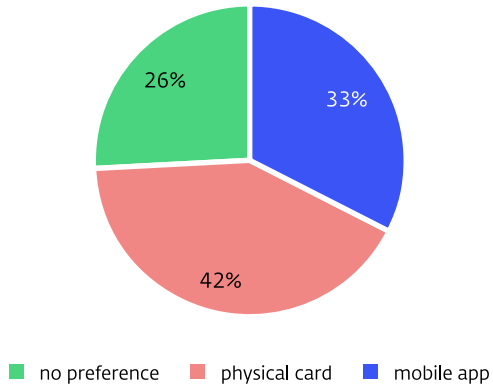


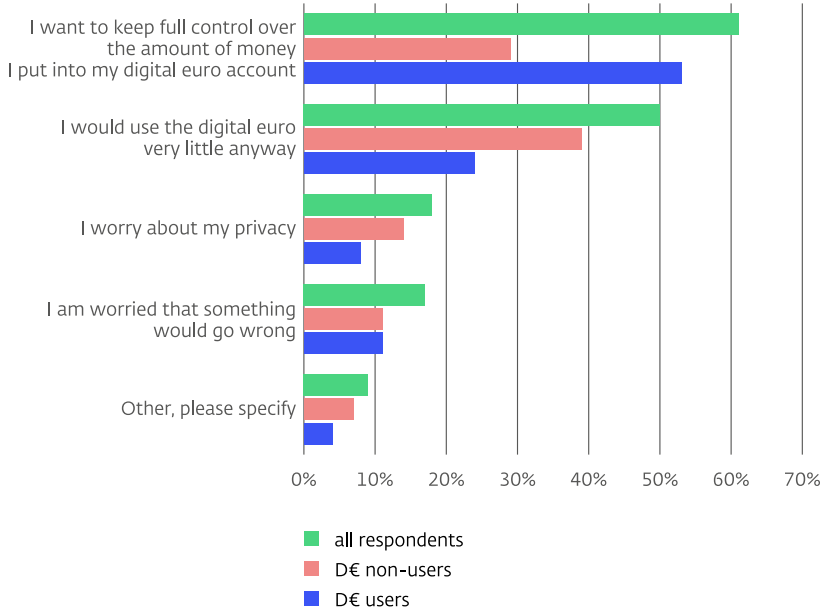
Table 15 Participants' form preferences for the digital euro across age categories

Age	18 to 39	40 to 49	50 to 64	65 and older
App on mobile phone	43%	38%	32%	21%
Physical card	38%	34%	41%	50%
No preference	19%	27%	27%	29%

Of all participants who used the digital euro in this experiment, 62% indicated they would like to make use of the automatic top-up function. When looking at all participants (including those who did not use the digital euro), a little over half (53%) indicated they would not want to make use of an automatic top-up function. We asked participants who indicated they would not want to make use of an automatic top-up function why they would not want to use it. The main reasons emerging are that participants want to

retain control and they do not expect to make a lot of use of the digital euro (see Figure 6). If we split the responses according to whether respondents used or did not use the digital euro in this experiment, we see that these two reasons for not wanting to use an automatic top-up function are still the most important two reasons for both users and non-users, but not in the same order. For non-users, the most important reason for not wanting to use the automatic top-up function is that they would use the digital euro very little anyway. For users, the main reason for not wanting to use the automatic top-up function is that they want to keep full control over the amount of money they put into their digital euro account.

Figure 6 Participants' reasons for not wanting to use an automatic top-up function for the digital euro



4 Discussion

This study was conducted to gain insight how future users of the offline digital euro will interact with and experience holding limits, both in situations where it is certain and uncertain that they can pay by debit card. This user perspective is not often highlighted, because holding limits are mostly considered from a macroeconomic perspective. The conclusions in this study may be useful to policy-makers in further shaping the characteristics of the digital euro.

Based on this research, we see a solid potential for the offline digital euro in the Netherlands from a user perspective. This is underlined by the fact that in our study a majority (two thirds) of participants were willing to use the offline digital euro. One third did not make use of the offline digital euro, mainly because they do not see the added value compared to current means of payment (cash and debit cards). Given that the Netherlands has a well-functioning digital payments system, this main reason is in line with our expectation. The second main reason indicated for not using the digital euro was unfamiliarity with the digital euro. This is in line with one of the findings from Bijlsma, van der Cruijsen, Jonker and Reijerink (2024) that intended CBDC usage is positively related to respondents' knowledge of CBDC. This shows that there is potential for central banks and governments to increase their communication efforts about the digital euro and its added value.

The offline digital euro behaves like cash. Participants prefer to carry less than €500 worth of offline digital euro, except for those who have a high monthly budget (€3,000) and face a situation in which it is not certain they can pay by debit card. A maximum of €1,298 for the (offline) digital euro (5% trimmed mean) is considered a logical limit among participants who used the digital euro in this

study. If people face uncertainty about being able to pay by debit card, they carry more offline digital euro and cash with them, with the digital euro being preferred over cash. The fact that the offline digital euro is used in the same way and alongside cash shows that both payment methods can co-exist.

This study shows that the currently often-cited total holding limit of €3,000 would likely not constrain day-to-day usability of the offline digital euro from an average Dutch user perspective. A higher digital euro holding limit may, however, be appropriate to accommodate varying preferences in the population. 12% of all participants have a preference for a holding limit higher than €3,000. It should be noted that the extrapolative power of this research regarding total digital euro holding limits is limited by the fact that we only focused on the offline digital euro. Nevertheless, what participants allocated to the offline digital euro (generally less than €500) and what digital euro users generally indicated as a logical maximum (€1,298 based on a 5% trimmed mean) reasonably fall within a total holding limit of €3,000, leaving the remainder as a potential holding limit for the online digital euro. It should, however, be noted that this study also reveals some exceptions and extremes, where a higher (offline) holding limit may be appropriate for a subset of the population. The highest average digital euro allocation in this study was made by digital euro users with a high budget facing uncertainty about whether they can pay by debit card, who on average allocated €1,276.39 to the digital euro. Moreover, 12% of all participants indicated a preference for a holding limit of more than €3,000.

Based on this study, the offline digital euro has the potential to add an extra layer of resilience to the Dutch payments landscape, which may serve as an additional consideration when setting the holding limit. One of the often-mentioned added values of an

offline digital euro is that it would increase resilience of the payments landscape alongside cash. A precondition to realising this potential is that users need to be willing to use the offline digital euro and pre-fund it. This study shows that the majority of participants are willing to allocate money to the offline digital euro and use it to pay, including for higher amounts. This study also shows that if people face uncertainty about being able to pay by debit card, they choose to carry more offline digital euro and cash with them, with the digital euro being preferred over cash. This means that there is potential for the offline digital euro to add to the resilience of our payments landscape by providing a reliable backup function alongside cash in situations where the regular payment infrastructure is not available. The offline functionality would also allow for payments without an internet or network connection. This resilience potential may also be an important factor to take into consideration when setting the holding limit. Within the total holding limit (online plus offline), there should be sufficient room for an offline holding limit to fulfil its resilience potential.

Overall, privacy does not emerge as a decisive argument for participants to make either more or less use of the digital euro. 68% of all participants indicated that privacy is not a factor in deciding to make either more or less use of the digital euro. This finding is in line with the study on the payment attitudes of consumers in the euro area (SPACE), where the Netherlands emerges as the country where consumers are least concerned about privacy in digital payments[2]. Nevertheless, when only looking at digital euro users in this study, slightly more than a quarter of users (28%) indicate that privacy would be a factor in deciding to make more use of the digital euro. As a public means of payment, privacy is therefore still an important condition, as is also concluded by Bijlsma et al. (2024).

2 In the SPACE study, one third of Dutch consumers (32%) were concerned about privacy when making digital payments.

The results for preferences for the design and functionalities of the digital euro mainly show a need to cater to varying preferences. The majority of participants (62%) using the digital euro would like to use an automatic top-up function. Considering this sentiment, it would be useful for central banks to explore whether the automatic top-up function mainly foreseen for the online digital euro (known as the (reverse) waterfall functionality) can also be applied in a similar or adjusted manner to the offline digital euro. Lessons can also be drawn from the main reasons participants in this study did not want to use the automatic top-up function. The main reasons were to retain control and because of little expected use of the digital euro. From the open responses, we learned that many participants worry about privacy being lost when linking the digital euro to their commercial bank account. This is something that central banks or governments may take into account when communicating about the (reverse) waterfall functionality. When it comes to the form factor, preferences show that the offline digital euro should be available as a card as well as an app, as is currently also foreseen in the design of the digital euro.

This research is subject to some limitations. This study focuses on the Netherlands, and further research is needed to determine whether similar patterns hold in other countries. Considering that this was an online experiment, the outcomes may not be representative of non-digitally savvy people. Other limitations of this study are that the focus is solely on the offline variant and that the characteristics of the payment methods were not described in full detail to the participants to avoid overly complicating matters.

In summary, our assessment is that the offline digital euro has potential for future users in the Netherlands. The findings suggest that the offline digital euro can add to the resilience of the payments landscape by providing a valuable backup function in situations where the regular payment infrastructure is not available.

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Annex Instructions for participants and questionnaire

Please note that the script below is an English translation of the Dutch script that was shown to participants in this study. Minor differences in interpretation may therefore occur. The script also includes some instructions given to programmers.

Page 1

Verification question

Page 2

We are conducting this survey on behalf of De Nederlandsche Bank. It is about people's preferences when making payments in shops.

This survey consists of two parts. The first part presents various situations you may encounter when making payments. In the second part, we ask some general questions. We are interested in your thoughts, feelings and actions in certain situations, and there are no correct or incorrect answers.

Participation in the survey is voluntary and can be withdrawn at any time. We will treat your data confidentially and your answers will not be traceable to you as an individual.

By clicking 'Next', you agree to participating in the survey and to the processing of your (anonymous) data.

Page 3

Thank you for participating in this survey. We ask that you read the information below carefully. For this reason, the 'Next' button will only appear after a while.

The central banks in the euro area are investigating the possibility of issuing a digital euro alongside cash, which all Europeans can use to make payments to each other, online or in a shop. In doing so, they will use their mobile or a debit card, just as with current payment methods. The digital euro is an electronic form of the coins and notes in our wallets. In other words, it is the digital form of cash.

Like cash, the digital euro will be issued and guaranteed by the central bank, making it a public means of payment. This is different from the digital payments we already use: these are managed by commercial financial firms such as banks, and are therefore private money. The digital euro will be a public complement to existing payment options, such as cash and debit card payments.

Like cash, the digital euro will be accessible and easy to use for everyone in the euro area. The level of privacy when making payments will be comparable to that of cash, so the central bank does not know who paid for what. The digital euro can also serve as a fall-back payment system, allowing payments to continue when other payment systems temporarily fail – for example due to card payment outages. The digital euro can also be used without internet or data connection via a special card or app on your phone, which also shows the balance.

This survey presents you with a number of situations. Please try to imagine what you yourself would do in each situation.

Page 4

V1 Please consider the following situation. Suppose you have a budget of <€800/€3,000> for this month.

You will have to make several payments in shops during the month. You will be asked to allocate your budget between your payment account at your bank, your digital euro account and cash. From your payment account, you can transfer money to your digital euro account and/or withdraw cash from an ATM. Below are the characteristics of the three payment methods. Please read them carefully:

	Payment account (debit card)	**Digital euro**	**Cash**
Payment form	Card or phone	Card or phone	Banknotes and coins
Payment coverage	Almost anywhere, unless there is a card payment outage	Anywhere, even if there is a card payment outage or if there is no network connection	Anywhere, even if there is a card payment outage or if there is no network connection
Interest	Yes, 1.5% annually	No	No
Privacy	No anonymous payments	Anonymous payments	Anonymous payments

How do you allocate your budget of <€800 or €3,000> ?
There are no correct or incorrect answers.
If you do not want to use a particular payment option, please enter 0.

€ ... - payment account
€ ... - digital euro
€ ... - cash

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'divide again' - certain scenario <half of participants first get the certain then the uncertain scenario, and the other half first the uncertain then the certain scenario>

	Payment account (debit card)	**Digital euro**	**Cash**
Most recent allocation	<show dynamically>	<show dynamically>	<show dynamically>
Payment form	Card or phone	Card or phone	Banknotes and coins
Payment coverage	Almost anywhere, unless there is a card payment outage	Anywhere, even if there is a card payment outage or if there is no network connection	Anywhere, even if there is a card payment outage or if there is no network connection
Interest	Yes, 1.5% annually	No	No
Privacy	No anonymous payments	Anonymous payments	Anonymous payments

v2 Suppose that your debit card is accepted in a shop 99 out of 100 times (debit card payment certainty = 99%). With this in mind, would you like to change the allocation of your budget between your payment account, digital euro account and cash, or not?

☐ Yes
☐ No

[if v2=yes]

v3 Allocate your budget of <€800 or €3,000> again.
If you do not want to use a particular payment option, please enter 0.

	Payment account (debit card)	**Digital euro**	**Cash**
Payment form	Card or phone	Card or phone	Banknotes and coins
Payment coverage	Almost anywhere, unless there is a card payment outage	Anywhere, even if there is a card payment outage or if there is no network connection	Anywhere, even if there is a card payment outage or if there is no network connection
Interest	Yes, 1.5% annually	No	No
Privacy	No anonymous payments	Anonymous payments	Anonymous payments
Previous distribution	<show dynamically>	<show dynamically>	<show dynamically>
New distribution	...	...	...

€ ... - payment account
€ ... - digital euro
€ ... - cash

Divide again – uncertain scenario

	Payment account (debit card)	Digital euro	Cash
Most recent allocation	<show dynamically>	<show dynamically>	<show dynamically>
Payment form	Card or phone	Card or phone	Banknotes and coins
Payment coverage	Almost anywhere, unless there is a card payment outage	Anywhere, even if there is a card payment outage or if there is no network connection	Anywhere, even if there is a card payment outage or if there is no network connection
Interest	Yes, 1.5% annually	No	No
Privacy	No anonymous payments	Anonymous payments	Anonymous payments

v4 Suppose your debit card is accepted in a shop 50 out of 100 times (debit card payment certainty rate = 50%). With this in mind, would you like to change the allocation of your budget between your payment account, digital euro account and cash?

☐ Yes
☐ No

[if v4=yes]

v5 Allocate your budget of <€800 or €3,000> again.
If you do not want to use a particular payment option, please enter 0.

	Payment account (debit card)	**Digital euro**	**Cash**
Payment form	Card or phone	Card or phone	Banknotes and coins
Payment coverage	Almost anywhere, unless there is a card payment outage	Anywhere, even if there is a card payment outage or if there is no network connection	Anywhere, even if there is a card payment outage or if there is no network connection
Interest	Yes, 1.5% annually	No	No
Privacy	No anonymous payments	Anonymous payments	Anonymous payments
Previous distribution	<show dynamically>	<show dynamically>	<show dynamically>
New distribution	...	...	...

€ ... - payment account
€ ... - digital euro
€ ... - cash

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We now present you with a new situation in which you want to pay for something in a shop. Please consider the following situation.

Debit card payment available high-low amount (2 situations)
<programmer: participants will be shown their most recent distribution in all four situations>

V6/V7 Suppose you are in a shop and want to pay for a product at the counter. This is a relatively <high/low> expense, amounting to [80%(high)/20%(low) of €<sum of digital and cash balance from last distribution>]. This is your first expense this month that you have to pay for with your budget of <€800 or €3,000>. Keep in mind that you may have to make more payments later this month.

Which payment option do you choose? <@programmer, please show balance in answer options. If the balance for one or more payment options is insufficient, show the answer option but make it unclickable, e.g. grayed out>

Payment options	Balance	
Debit card (payment account)	<Show dynamically based on most recent distribution>	o
Digital euro	<Show dynamically based on most recent distribution>	o
Cash	<Show dynamically based on most recent distribution>	o

☐ Debit card (payment account)
☐ Digital euro
☐ Cash

Debit card payment not available high-low amount

v8/v9 Suppose you are in a shop and want to pay for a product at the counter. This is a relatively <high/low> expense, amounting to [80%(high)/20%(low) of €<sum of digital and cash balance from last distribution>]. This is your first expense this month that you have to pay for with your budget of <€800 or €3,000>. Keep in mind that you may have to make more payments later this month.

Due to a card payment outage, you cannot use your debit card. Which payment option do you choose?

<if both the digital euro and cash balance are sufficient to make the payment, show both options of which only one can be selected>

☐ Digital euro
☐ Cash

<if the sum of the digital euro and cash balance is sufficient but not either of these separately, show both options, with selecting them both as the only possible answer>

☐ Digital euro
☐ Cash

<if the sum of the digital euro and cash balance is 0, then change the question and answer options to the following:>

Suppose you are in a shop and want to pay for a product at the counter. This is a relatively expensive item. This is your first expense this month that you have to pay for with your budget of <€800 or €3,000>. Keep in mind that you may have to make more payments later this month.

Due to a card payment outage, you cannot use your debit card. You also do not have any digital euro or cash with you. What would you do? <1 possible answer option>

- ☐ I would go to an ATM to withdraw cash.
- ☐ I would top up my digital euro account.
- ☐ I would put the product back and not buy it right now.

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[If a participant allocated €0 to the digital euro account in at least 1 of the sub-scenarios]

V10 In (at least) one of the situations where you allocated your money between the three payment options, you chose not to transfer any money to your digital euro account. Why did you choose not to transfer any money to your digital euro account? (select all that apply)

- ☐ I do not trust the central bank/government
- ☐ I do not trust the digital euro
- ☐ I do not know enough about the digital euro
- ☐ I do not feel the need to do so, I am happy with the other means of payment available
- ☐ I have privacy concerns
- ☐ It seems like a lot of hassle to transfer money to a digital euro account
- ☐ Other, please specify

Page 10

V11 The central bank cannot see what you pay for with digital euro. Would privacy be a reason for you to make more or less use of the digital euro? Please indicate which statement suits you best.

- ☐ The privacy offered by the digital euro would be a reason for me to use it more.
- ☐ The privacy offered by the digital euro would not be a reason for me to use it any more or any less.
- ☐ The privacy offered by the digital euro would be a reason for me to use it less.

V12 Suppose there is a limit to the maximum amount of euro you can have in your digital euro account, what would you consider a logical amount based on your own daily life? (open question)

€...

Page 11

V13 In this survey, you had to transfer money to your digital euro account before you could pay with the digital euro. This is similar to having to withdraw cash from an ATM before you can pay with it. Suppose you could link your payment account to your digital euro account, automatically topping your digital euro account up when the balance gets too low. Would you make use of this automatic feature in your daily life?

- ☐ Yes
- ☐ No

[If v13=no]

v14 Why would you not want to use this automatic top-up option? (select all that apply)

- ☐ I want to keep full control over the amount of money I put into my digital euro account.
- ☐ I am worried that something would go wrong.
- ☐ I worry about my privacy.
- ☐ I would use the digital euro very little anyway.
- ☐ Other, please specify:

v15 Which form of the digital euro would you prefer?
Please select an answer even if you do not expect to use the digital euro often or if you do not expect to use the digital euro at all.

- ☐ An app on a mobile phone
- ☐ A card
- ☐ I do not have a preference.

Final Page

Your answers are important to De Nederlandsche Bank. We would like to thank you for your time and cooperation.

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