NORGES BANK PAPERS

# Central bank digital currencies

NO. 2 | 2019

SECOND REPORT OF WORKING GROUP

NORGES BANK

# Norges Bank Memo NO. 2 | 2019



Norges Bank

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ISSN 1894-0277 (online)
ISBN 978-82-8379-105-1 (online)

# Contents

# Preface

Various central banks are considering whether to issue generally accessible electronic money in future. Like cash, such money represents a claim on the central bank of the country in question, and is denominated in that country's official unit of currency.

Technological advances have increased the relevance of this topic. Norges Bank will issue cash for as long as appropriate. Nevertheless, falling cash usage requires us to consider whether new instruments will be needed in future to safeguard an efficient, robust payment system and confidence in the monetary system. If the answer is yes, a central bank digital currency may be a suitable measure for averting weaknesses that could otherwise arise.

In Norges Bank Papers No. 1/2018, a working group from Norges Bank presented an overview of factors to which emphasis should be given when evaluating whether Norges Bank should introduce a central bank digital currency. In this second report, the working group has taken a closer look at potential purposes to be achieved by any central bank digital currency, as well as alternative means of achieving these.

The working group has considered whether a central bank digital currency could be a necessary supplement to cash, as a means of:

- Providing an independent back-up solution for ordinary electronic payment systems and ensuring that payments can always be made, including in the event of substantial changes in market structure and the stakeholder profile.
- Safeguarding access to credit risk-free money.
- Ensuring satisfactory competition in the markets for means of payment and payment instruments.
- Providing suitable legal tender.

The working group has also considered how necessary and desirable characteristics of a central bank digital currency could be safeguarded, by reference to two primary solution categories:

- Token-based money, where value is represented directly by the token.
- Account-based money, where value is linked to the balance of an account belonging to an identifiable account holder.

Central bank digital currencies raise complex issues. We have little international experience to draw on. More information is required before a conclusion can be reached as to whether a central bank digital currency is an effective means of promoting a secure, efficient payment system and continued confidence in the monetary system.

In the third phase of its work, the working group will conduct a more detailed assessment of the proposed solutions and what they will require in terms of technology development. Consideration will also be given to consequences for the payment system, financial stability and monetary policy. Further, the working group will monitor international discussions relating to central bank digital currencies and evaluate purpose-related questions. A guiding principle of this work is that the existence and scope of such money should not undermine the scope for credit provision in the private sector.

This is a long-term project. The objectives behind publishing the working group's report are to inform about the work being done, share knowledge and encourage dialogue.

Øystein Olsen

# 1. Introduction and summary

A central bank digital currency (CBDC) is a digital form of central bank money denominated in the official unit of account for general purpose users. A CBDC can take several forms with different characteristics, depending on its purpose.

A Norges Bank working group[1] has completed the second phase of a study of CBDCs. This second report is based on the working group's first report; see Norges Bank (2018).

**Main question**
Our primary question in the present report is whether a CBDC is necessary and desirable to ensure that Norway maintains a secure and efficient payment system, and confidence in the monetary system, going forward.

In our view, a CBDC could function as a contingency solution in case of failures in bank payment systems. The contingency perspective may grow in importance if payment infrastructure becomes increasingly internationalised. Moreover, a CBDC could help maintain competition between different means and instruments of payment. At the same time, the introduction of a CBDC does not appear necessary to ensure that the public has access to a secure means of payment. Moreover, the need to adopt a legal tender equivalent to cash does not, on its own, justify the introduction of a CBDC.

The working group requires more information to be able to conclude whether introducing a CBDC is an appropriate means of fostering a secure and efficient payment system and continued confidence in the monetary system.

The group's recommendation is that it should now conduct a concrete assessment of whether a CBDC in the form of register-based token money or a closed account-based solution could safeguard the characteristics defined as necessary and desirable. There is also a need to clarify what technology development is required to achieve these characteristics. Finally, further consideration has to be given to consequences for the payment system, financial stability and monetary policy.

**CBDC characteristics**
Central banks in different parts of the world are evaluating CBDCs, albeit from at times widely varying perspectives due to their differing fiscal structures. A distinguishing characteristic of Norway is its low and falling cash usage. It is possible that, at some point, cash usage will be so low that cash can no longer be considered a generally available means of payment.

Cash has a number of important characteristics. Accordingly, we have considered whether the best way of preserving these characteristics in response to falling cash usage is to introduce a CBDC. We have also discussed whether a CBDC could support a payment system that better meets future needs. Could introducing a CBDC reinforce certain characteristics while also helping to preserve key characteristics of cash?

[1] The working group comprised Knut Sandal (chair), Ragna Alstadheim, Tom Bernhardsen, Kjetil Heltne, Arne Kloster, Helge Syrstad, Ylva Søvik, Leif Veggum, Peder Østbye, Terje Åmås and Steinar Årdal. Kjetil Watne, Njål Stensland and Monique Erard participated in an early phase. Cyril Monnet (University of Bern) and Wilko Bolt (De Nederlandsche Bank) assisted the working group with parts of the analysis. The project's steering group comprised Torbjørn Hægeland (chair), Ida Wolden Bache, Olav Bø, Marius Ryel and Kasper Roszbach.

We have taken a closer look at a number of relevant objectives a CBDC could serve:

- To function as an independent back-up solution for the ordinary electronic payment systems.
- To ensure access to credit risk-free money.
- To ensure satisfactory competition in the markets for means and instruments of payment.
- To ensure the existence of suitable legal tender.

We refer to Norges Bank (2018) for a broader analysis of potential CBDC objectives. We would emphasise that our conclusions as to both purpose and design are tentative, and may change over time as payment system structures evolve and new knowledge is gained.

**Independent back-up solution**
In addition to being a means of payment, a CBDC can also function as an independent payment system. A CBDC can secure technical autonomy from ordinary payment systems and national control. The latter may become particularly important if other payment infrastructure is relocated outside Norway's borders and the Norwegian authorities are thus able to exercise only limited or no control.

Various instruments can be employed to secure a back-up solution. For example, enforcement of the statutory duty of banks to provide cash services can help preserve the back-up function of cash in contingency situations. While a CBDC is not manifestly necessary for back-up reasons, it may be desirable based on a cost-benefit analysis of a given solution.

A design requirement for any CBDC solution should be that it is capable of functioning independently of bank payment systems, and of implementing "offline" payments for a certain period. Back-up solutions for systems based on bank deposits can ensure the accessibility of payment systems, but will not remedy a situation where confidence in the banking system is greatly reduced or lost.

**Credit risk-free alternative to bank deposits**
A possible argument why the central bank should offer a credit risk-free means of payment is to safeguard public access to a secure means of payment.[2] A key question is to what extent bank deposits already meet this need. Bank deposits appear to constitute a sufficiently secure and general means of payment. Given the regulatory framework, deposit protection and the central bank – which can provide banks with liquidity – it seems likely that the public will have access to a secure means of payment even if cash disappears. The deposit guarantee scheme features some liquidity risk, but no credit risk. While there is some residual credit risk over and above the deposit guarantee scheme, it seems that this applies particularly to businesses. Further, in practice cash holdings do not currently offer a solution to this problem.

In view of the present regulatory framework for the financial system in Norway, it appears unnecessary to introduce a CBDC for the purpose of safeguarding public access to a secure means of payment.

**Competition**
Although demand for cash is falling, cash may still be important for competition in the markets related to means and instruments of payment, as it offers users an alternative to deposit money. The strength of this effect is difficult to establish. The markets for private means and instruments of payment are concentrated, but competition and market regulations currently appear to be promoting efficiency. On the other hand,

[2] What we are referring to here is whether the value of the means of payment is sufficiently secure given the current regulatory framework. A secure payment system also includes other factors, such as technical security.

electronic payment services are characterised by economies of scale and network effects, which may play a part in restricting competition. Depending on market developments, there is some risk that eliminating cash will undermine competition and provide scope for monopolistic/oligopolistic gains. In isolation, competition-related considerations thus indicate that the introduction of a CBDC is desirable, although the necessity of doing so is uncertain. Regulating access to cash may help maintain competition linked to certain payment types, but cannot expand the scope of competition to include other types of payments like a CBDC could.

**Legal tender**
There are good reasons for having legal tender which gives the parties to a payment settlement a fall-back solution in case they fail to agree the method of payment. Cash is legal tender at present, and will remain so under the new Norges Bank Act. As a supplement to cash, a CBDC could safeguard all the characteristics legal tender should have. Further, a CBDC could expand the area of application of legal tender compared to cash, as a CBDC can be used for distance payments and can be traced. However, we do not see that the consideration of legal tender alone justifies the introduction of a CBDC at this juncture.

**Effects of a CBDC and the precautionary approach**
The above discussion shows that a CBDC could be desirable because it can:

- function as an independent back-up solution in case confidence in the banking system declines significantly or electronic back-up solutions prove insufficient. The back-up perspective may grow in importance if payment infrastructure is internationalised
- intensify competition in the payment market
- offer all the characteristics of legal tender

On the other hand, the introduction of a CBDC is associated with considerable costs and risk. Any assessment examining the overall desirability of a CBDC must therefore reflect a socioeconomic cost-benefit analysis of a closely specified solution, and the introduction of a CBDC must be compared to alternative means of achieving set objectives.

A cost-benefit analysis will not necessarily encompass the precautionary approach. Being well-prepared for the introduction of a CBDC may well be a sound strategy in case the payment system and means of payment develop in an unforeseen direction or at a different pace than currently anticipated. For example, a material change could occur in the market structure and stakeholder profile as a result of which bank deposits in Norwegian kroner and a Norwegian-controlled payment system are no longer dominant. Accordingly, a CBDC could function as a “safety valve” in case of developments in the payment system that reduce Norges Bank’s room to perform its tasks.

An important balancing exercise to be performed by Norges Bank when considering the introduction of a CBDC is between the benefits to the public of being able to hold a credit risk-free means of payment and the potential negative consequences for availability of credit in the real economy and management of the central bank balance sheet. This balancing exercise is the same regardless of whether the public wishes to hold cash, a CBDC or deposits in full-reserve banks. This is described further in Norges Bank (2018). At the same time, Norges Bank has differing opportunities to influence the alternatives.

Demand for such credit risk-free alternatives may vary. At present, demand for cash is low, and probably fairly interest-inelastic. We do not know how large a premium the public is willing to pay for an electronic alternative, or how the premium will vary in line with interest rates and uncertainty in the financial system. There are indications that the premium on such assets is low, but this may change. While uncertainty also attaches to how banks will adapt to lower demand for deposits, deposit rates and the

proportion of market financing appear likely to increase. Although it is not given that such a change will reduce the availability of credit in the economy, this possibility cannot be excluded.

**Choice of design**
We have evaluated how necessary and desirable characteristics of any CBDC can be achieved through different variants of solutions in two main categories:

- Token-based money, where value is represented directly by the token.
- Account-based money, where value is linked to a balance in an account belonging to an identifiable account holder.

Based on an overall assessment of which solutions best safeguard necessary and desirable characteristics, we recommend that further work now be done on:

- a CBDC in the form of register-based token money (the main solution).
- a CBDC as a closed account-based solution offering the possibility of storage on a physical device (alternative solution).

In the first solution, the integrity of the solution will be ensured by means of a continuously updated transaction register. Unlike a bank account, the register is not linked to an identity, but rather to cryptographic codes and keys. Users control the CBDC via a user interface, for example a mobile application, which communicates with the register. Since the money is linked to a register and the user interface is only used to access the money, the money will not be lost if the mobile telephone or card is lost or damaged. If the cryptographic keys to the register are lost, however, the money may be lost.

The second solution has similarities with closed account solutions offered by e-money institutions like PayPal. Both the payer and the payee must have an account in the system in order for a transaction to be implemented. Settlement takes the form of debiting and crediting of customer accounts internally within the system. The system can be designed to be independent of bank payment systems and payment instruments in a payment situation.

These two solutions may offer necessary and desirable characteristics, and have the potential to be sufficiently attractive to secure a desirable degree of use. They offer flexibility with respect to future developments and changing needs. However, their development will take time and entail costs. They are not candidates for introduction in the short or medium term. A simplified solution could probably be developed more quickly if deemed necessary.

At this juncture, we do not recommend further examination of a solution featuring the storage of money solely on physical devices, or of an ordinary open account solution. A system under which money is only stored on physical devices will have many of the same characteristics as cash. In principle, this serves the purpose of a CBDC. The disadvantage is that the solution will be “too similar” to cash, and use is likely to be low for several of the same reasons as are driving low and falling cash usage. It is therefore unlikely that the solution would ensure retention of the characteristics of cash. Ensuring continued access to cash is a better alternative in this regard.

An open account solution will have to be integrated with bank payment solutions, and will be a close substitute for an account with a private bank, except that credit will not be offered. This may be a disadvantage compared to an independent back-up solution. Customers are likely to expect to be able to use bank payment solutions, and may lack incentives to open a CBDC account because they can still receive money transfers from persons with a CBDC account into their ordinary bank accounts. This may also be a disadvantage in terms of scope for preventing the transfer of a considerable proportion of deposits out of private banks. Nevertheless, in our view

emphasis should be given to whether a design can be scaled to an open solution when choosing the design for the closed account-based solution.

**Conclusion and way forward**

In our opinion, more information is required before a conclusion can be reached on whether introducing a CBDC is an appropriate means of promoting a secure and efficient payment system and continued confidence in the monetary system.

A concrete assessment should be conducted of whether the two proposed solutions are capable of safeguarding necessary and desirable characteristics, and of what technology will have to be developed to achieve this. The solutions must be described in far greater detail, and the main elements of the requirements specification must be listed. Consideration must also be given to consequences for the payment system, financial stability and monetary policy. It will also be useful to monitor international views on CBDCs and evaluate individual issues related to the overall objectives.

# 2. The purpose of central bank digital currencies

## 2.1. Introduction

The working group has taken a closer look at some of the relevant purposes of a CBDC identified in Norges Bank (2018).

The purposes are generally linked to the characteristics of cash. The question is whether a CBDC is necessary and desirable as a supplement to cash which ensures preservation of these characteristics in a situation where cash is gradually losing significance as a generally available means of payment.

We have also considered whether a CBDC could promote a payment system which better meets future needs. Are there characteristics which a CBDC could reinforce while also ensuring the preservation of important characteristics of cash? This applies particularly to two functions: cash as a back-up solution and cash as legal tender.

We have not given detailed consideration to whether a CBDC designed for use by all could generate socioeconomic gains in the context of settlement between financial stakeholders.[3] However, we have taken into account that this could be a positive additional characteristic when choosing a design.

We have concentrated on the following purposes:

- independent back-up solution
- credit risk-free alternative to bank deposits
- competition
- legal tender

Incidentally, these matters are also being considered by Riksbanken (the central bank of Sweden) in its “e-krona” project. Like Norges Bank, Riksbanken has adopted the starting point that cash usage is low and falling, and is considering whether there is a need to retain central bank money in a different form to preserve important characteristics of the payment system; see Ingves (2018), Riksbanken (2018) and Riksbanken (2019).[4] Central banks all over the world are discussing potential purposes of and designs for a CBDC. The wide variety of approaches under consideration reflects the broad range of affected financial sectors.[5]

## 2.2. Independent back-up solution

In implementing reserve and back-up solutions, society chooses to incur a limited ongoing cost to avert high costs during potential crises.

Fundamentally, it is desirable that the public should always be able to make payment. This demands both redundancy and an independent back-up solution.

[3] A potential example is securities settlement, where a CBDC with certain technical characteristics may possibly provide a better link between the monetary and securities aspects of settlement. Several central banks have considered this in greater detail; see CPMI (2018) and Barontini and Holden (2019) for an overview.
[4] Riksbanken has also decided to develop a technical pilot for a CBDC to gather experience; see Riksbanken (2018).
[5] Mancini-Griffoli et. al. (2018), CPMI (2018) and Barontini and Holden (2019) provide an overview of the work of different central banks. Sedlabanki Islands (2018) expands on the assessments conducted by Sedlabanki.

Redundancy describes the availability of two or more solutions capable of taking over for one another, for example if one solution suffers operational problems. A seamless takeover is only possible if the solutions mirror one another and either run in parallel or are ready to do so immediately. For example, two identical operational locations can be set up such that production can be switched between them.

Seamless redundancy is beneficial in terms of accessibility, but not necessarily a good back-up solution. Mirroring means that both solutions could be equally affected by an error. Examples include software errors and corrupted data.

Moreover, a back-up solution has to be protected against the errors to which operational solutions are vulnerable. Back-up solutions are typically not "hot", do not rely on the same technology and other infrastructure, and are situated sufficiently far away in geographical terms. An alternative is to adopt multiple, entirely independent payment solutions to function as back-ups for one another.

Accordingly, both redundancy and back-up solutions are required. Situations may arise in which adjustments have to be made to such solutions based on a cost-benefit analysis. However, the requirement of a satisfactory back-up solution can never be dropped in respect of critical infrastructure required to meet society's payment needs.

Effective electronic back-up solutions are vital for rapid re-establishment of the payment system following a stoppage. Cash is part of the overall back-up solution in the event of any failure in electronic back-up systems.

As pointed out by Norges Bank in its reports on financial infrastructure, the current back-up solution for the payment system has deficiencies.

In general terms, the most important measures to reinforce the back-up solution for payments are as follows (not in priority order):

1. Regulate private payment solutions by
    a. imposing requirements on the owners of specific payment solutions
    b. regulating and monitoring critical payment system suppliers
    c. requiring back-up solutions for general solutions, such as terminals.
2. Ensure the continued availability of cash by regulatory and other means, by
    a. requiring banks to offer cash deposit and withdrawal functionality in any contingency situation; see section 16-4 of the Regulations relating to the Financial Institutions Act
    b. as part thereof, requiring back-up solutions for ATMs
    c. requiring banks also to offer cash services in non-contingency situations
    d. requiring or urging the public to hold some cash and a stock of basic necessities (thus reducing the need to make payments); see the contingency list maintained by the Norwegian Directorate for Civil Protection.
3. Introduce a CBDC system which is operationally independent of ordinary payment systems. Any CBDC system could also be an instrument for ensuring national control if payment infrastructure is relocated outside Norway.

The present report does not include a detailed assessment of contingency situations and the most appropriate measures or combinations of measures to be implemented.

The assessment as to whether introducing a CBDC is desirable for contingency reasons must be based on a socioeconomic cost-benefit analysis of a specific solution, and include a comparison with alternative measures. Any analysis of a CBDC solution should include the requirements that it can function independently of bank payment systems and can facilitate offline payments for a certain period of time.

As a formality, we would note that this discussion relates primarily to technical back-up solutions. Back-up solutions for bank deposit-based systems will not remedy a situation where confidence in the banking system is greatly reduced or lost.

## 2.3. Credit risk-free alternative

The Norwegian banking system can be split into two levels. The first comprises private banks and the public. The second consists of private banks and Norges Bank.

On the first level, private banks provide banking services to the public in the form of deposits, loans and payment services. Through their lending activities, they create deposits (deposit money). This form of money is currently the dominant means of payment used by the public in Norway.

Norges Bank is the bank of banks. On the second level of the banking system, Norges Bank provides banking services to private banks in the form of deposit and lending arrangements. Norges Bank is the only issuer of central bank reserves, the means of payment used in inter-bank settlement. By providing loans and deposit facilities for central bank reserves, Norges Bank helps alleviate some of the liquidity risk incurred by banks when providing banking services to the public. The public, on the other hand, has no access to central bank reserves.

Cash represents a deviation from this two-level model, in that it is the only means of payment issued by Norges Bank to which the public has access. The public is free to choose between bank deposits and cash. Both can serve as both a means of payment and a store of value.

However, cash usage is declining. Cash accounts for a steadily decreasing proportion of money supply, and is less used in payment transactions than previously. Nevertheless, even if demand falls, cash may be significant with regard to public confidence in the monetary system.

A key question is to what extent bank deposits already meet the need for a secure and generally available means of payment. This currently appears to be the case in Norway. Regulations, deposit protection and Norges Bank's role as a source of bank liquidity[6] are likely to provide the public with access to a secure means of payment even if cash disappears. Businesses' cash deposits will often exceed the deposit protection maximum. Deposits from small and medium-sized enterprises enjoy preferential treatment in the context of crisis management and public administration, rendering credit risk negligible for these entities. On the other hand, credit risk may be real for large businesses. However, in practice cash holdings are not a solution for businesses seeking to avoid credit risk.

Deposit protection and crisis management of banks are not dependent on the existence of cash. If a bank goes bankrupt, deposits covered by the deposit protection scheme will in most cases be paid into other bank accounts, not disbursed in cash. This may create liquidity risk for the account holder, in that a few (but no more than seven) days may pass before money is disbursed. Given how rarely such situations have arisen, however, such liquidity risk does not appear to threaten the position of bank deposits as a secure means of payment. Moreover, the continued decline in cash usage in Norway, even following a financial crisis, may indicate that the public largely has confidence in deposit money.

Most Norwegians have access to a bank account and associated technology like payment cards and payment apps for mobile telephones. Some people, such as the elderly, may feel that such technology is difficult to use in practice. However, a CBDC

[6] Norges Bank does not issue loans to banks which are, or are likely to become, insolvent.

would also demand technical solutions. The fact that some individuals encounter technical hindrances to the use of bank deposits as a means of payment is a stronger argument in favour of ensuring continued access to cash than in favour of introducing a CBDC.

Retaining the current stability framework based on regulations, deposit protection and the central bank as a source of bank liquidity is also associated with costs. These include both public and private administrative costs and costs resulting from unintended regulatory effects. One important unintended effect of deposit protection and central bank liquidity facilities is that banks may take on excessive risk – so-called moral hazard. In addition, new systemic risks are likely to arise in future, and regulations and protection schemes will often lag behind developments. Nevertheless, bank deposits appear to be a sufficiently secure and generally available means of payment. Introducing a CBDC will not necessarily eliminate or reduce regulations and protection schemes, or the costs associated with them.

## 2.4. Competition

Although demand for cash is falling, cash may influence competition in the markets for means of payment and payment instruments by offering users an alternative to deposit money. The strength of this effect is difficult to determine. The markets for private means and instruments of payment are concentrated, but at present competition and regulation of these markets appear to be ensuring efficiency.

Low and falling cash holdings may indicate that cash is being out-competed by deposits in terms of its function as a store of value. Even though cash is most competitive against deposits when interest rates are close to zero, cash holdings have continued to decline despite historically low rates. In addition, the public has shown some willingness to accept negative interest rates on deposits.

The use of cash as a payment instrument is also falling, and competition from new electronic payment solutions is likely to be more important for the efficiency of this market going forward. Regulatory provisions like the revised Payment Services Directive (PSD2) are intended to foster competition in the payment instruments market.

At the same time, it must be concluded that the existence of cash is helping to keep payment service prices down. Electronic payment services are characterised by economies of scale and network effects which could limit competition. This also applies to banking systems in Norway, and cash is in many respects the only current alternative. Since we have no experience of an entirely cashless system, it is difficult to conclude as to the size of this effect. Regulating access to cash can help maintain competition for certain types of payments, but cannot expand the scope of competition to include other types of payments. A CBDC, on the other hand, could achieve this.

Introducing a CBDC could potentially boost competition in the market for storage of means of payment. However, if no interest is paid on the CBDC, it will not increase competition with bank deposits at normal interest rate levels (the return on bank money makes it more attractive than the CBDC). Conversely, if interest were to be paid on the CBDC, competition could also be boosted in this market at normal interest rate levels. Increased competition for deposits would mean higher financing costs for banks. Depending on its design and Norges Bank's pricing of its share of the services involved, a CBDC could also intensify competition in the payment instruments market. Generally speaking, competition would also be felt in other areas than price/interest rate – primarily user-friendliness and fulfilment of user needs.

It is uncertain how any future loss of cash which is not replaced by a CBDC would impact on competition. At present, the effect of cash on competition appears limited, although we lack an adequate basis for a definite conclusion. This applies not only to

competition linked to bank deposits, but also to the effect on competition in the market for payment services. If cash disappears, by and large only bank payment solutions will be left.[7] Depending on market developments, there is a risk that eliminating cash will undermine competition and provide scope for monopolistic/oligopolistic gains.

The present situation, in which there is a generally available means of payment in the form of bank deposits, can probably be maintained by regulatory means and inter-bank competition. The public sector has a role to play in protecting the access of vulnerable groups to private-sector payment services, and in ensuring that cash can continue to be used.

## 2.5. Legal tender

There are good reasons for having a means of payment which is given the status of legal tender. This provides the parties to a payment settlement with a fall-back solution in case they cannot agree on a payment method. In principle, the parties are free to decide how payment should occur. The rule on legal tender, see section 3-5, first paragraph, of the new Norges Bank Act,[8] applies where parties have not agreed a payment method. At present, Norges Bank's notes and coins are mandatory means of payment. This means that, in the absence of a specific agreement to the contrary, either party to an agreement may demand that payment be made in notes and coins on the due date, and the other party has no right to object to this. This allows the parties to avoid the effects of a breach of contract. Alternatively, the payment method may be regulated by law or regulation, in which case the provision on mandatory means of payment does not apply.

A rule specifying a fall-back solution in case of disagreement (a fall-back rule) will promote efficiency by resolving disputes. In the absence of such a fall-back solution, disagreement about the payment method will in practice be resolved by the creditor using his or her right to issue instructions, see section 38(2) of the Financial Contracts Act, which provides that, "[t]he payee may give further instructions concerning the method of payment, provided this does not entail a substantial additional expense or other inconvenience for the payer." The existence of a fall-back rule on legal tender helps ensure that a payee cannot unilaterally impose a payment method which is unfavourable to the payer.

This is because the right to issue instructions is restricted by the payee not being able to dictate payment methods which are less favourable than using legal tender.

Further, it may be the case that a payer lacks access to the means of payment specified by the payee. In the absence of a fall-back rule on legal tender, one of the parties – usually the payer – may be in breach after the due date.

The existence of a means of payment which the public knows can be used in most settlements is advantageous in itself. If it were to be left to the parties to a payment settlement to agree the means of settlement in all cases, the stronger party to the settlement would be able to force, systematically, the weaker party to accept the payment method which is to the stronger party's advantage. The existence of a generally accepted means of payment which the parties agree may be used unless specified otherwise gives the assumed weaker party to a payment settlement some protection against enforcement of a disadvantageous payment method. This consideration primarily applies in the consumer context, where it must be assumed that negotiating power is asymmetrical. The rule on legal tender thus holds some relevance for consumer protection. In Norwegian legislation, this is apparent

[7] New, non-bank payment providers are entering the market and may boost competition, at least in the short term. However, network effects and economies of scale may reduce competition in the longer term; see also the discussion in chapter 2.6.
[8] See discussion of the new Norges Bank Act in chapter 5.

particularly from the provision in section 38(3) of the Financial Contracts Act, which states that consumers have an unconditional right "to effect settlement with the recipient of the payment in legal tender".

The working group has concluded that there are still good reasons for having a rule on legal tender. Under the new Norges Bank Act, cash is retained as legal tender; see section 3-5, first paragraph. If a CBDC were to be introduced, it could be given status as legal tender alongside cash. A CBDC has all the characteristics legal tender should have. Further, a CBDC could expand the area of application of legal tender, as a CBDC can be used for distance payments and can be traced. However, we do not see that the consideration of legal tender alone justifies the introduction of a CBDC at this juncture.

## 2.6. Effects of a CBDC and the precautionary approach

No complete cost-benefit analysis has been conducted of the introduction of a CBDC. Nevertheless, we would point out a number of relevant circumstances and competing considerations.

On the one hand, we see that a CBDC could:

- function as an independent back-up solution in case confidence in the banking system declines materially or electronic back-up solutions prove insufficient. The consideration of back-up capacity may increase in importance if payment infrastructure becomes more international
- strengthen competition in the payment market
- safeguard all the characteristics of legal tender and, if desirable, expand the area of application

On the other hand, as pointed out in Norges Bank (2018), the introduction of a CBDC is associated with financial costs and other potential disadvantages and risks.

**Consideration of potential negative consequences**
An important balancing exercise to be performed by Norges Bank when considering the introduction of a CBDC is between the benefits to the public of being able to hold a credit risk-free means of payment and the potential negative consequences for availability of credit in the real economy and management of the central bank balance sheet. This balancing exercise is the same regardless of whether the public wishes to hold cash, a CBDC or deposits in full-reserve banks. This is described further in Norges Bank (2018). At the same time, Norges Bank has differing opportunities to influence the alternatives.

Demand for such holdings may vary. At present, demand for cash is low, and probably fairly interest-inelastic. We do not know how large a premium the public is willing to pay for an electronic alternative, or how the premium will vary in line with interest rates and uncertainty in the financial system. Since the existing full-reserve bank in Norway has not received notable deposits, there are indications that the premium on such assets is low, but this may change. While uncertainty also attaches to how banks will adapt to lower demand for deposits, deposit rates and the proportion of market financing appear likely to increase. Although it is not given that such a change will reduce the availability of credit in the economy, this possibility cannot be excluded.

**The precautionary approach**
A cost-benefit analysis will not necessarily encompass the precautionary approach. Being well-prepared for the introduction of a CBDC may well be a sound strategy in case the payment system and means of payment develop in an unforeseen direction. For example, a material change could occur in the market structure and stakeholder

profile as a result of which deposits in private banks in Norwegian kroner and a Norwegian-controlled payment system are no longer dominant.

Two possible substantial structural changes are:

- relocation of bank payment infrastructure abroad
- stronger competition for banks from international “big-tech” companies.

A relevant example of the first type of change is the P27 initiative focused on a joint Nordic payment infrastructure. Norwegian banks have recently decided not to participate. Other initiatives may emerge. If central payment infrastructure operates outside Norway’s borders, a new look must be taken at back-up solutions located in Norway. Both location and national control will be important considerations in this regard.

A further potential development is that major international “big-techs”/platform companies may become important stakeholders in trading and payments by the Norwegian public, in addition to their prominent role in communications and social life. The advantages in terms of networks, access to information and economies of scale may further strengthen the market position of these companies over time. Barriers to entry may increase as ever greater investment is required to be able to compete, thus reinforcing the market power of the biggest companies.

The current payment strategy of such companies is to offer a user interface “on top” of the traditional payment system. However, it is entirely possible that companies will penetrate ever lower levels of the payment system in the longer term, offering customers the possibility of depositing money with them and making payments through the system. One example is Alipay’s business in China. On 18 June 2019, Facebook announced plans to launch, in cooperation with selected partners, a proprietary monetary unit called Libra, as well as a DLT-based payment system. Libra is an example of a so-called "stablecoin" solution, where value stability is sought by linking the monetary unit with a basket of currencies. Questions arising related to the development of solutions outside the traditional payment system include whether payments will be denominated in Norwegian kroner, how large a proportion of their wealth Norwegian customers will want to hold in such solutions and what influence Norwegian banks will have over the payment system and the economy.

In a payment universe dominated by international platform companies, challenges may thus arise with regard to competition, data protection and back-up solutions. What options are there for disciplining big-tech companies if other private (and Norway-based) stakeholders are squeezed out?[9] Further, how can we ensure that the Norwegian public is always able to make payments, if payment systems are located and managed from abroad?

A CBDC can function as a safety valve in the event of developments in the payment system which could undermine Norges Bank’s ability to perform its tasks. This development is not expected, but is possible. It may therefore be a sound strategy to gather knowledge about the potential design of a CBDC system. Moreover, it may well prove more difficult to introduce a CBDC if we wait until the market has made significantly steps in the direction outlined above.

[9] Another type of challenge is that some instruments for managing the Norwegian economy may be weakened. This is not discussed further in the present report.

# 3. Alternative solutions for central bank digital currencies

In this chapter, we describe necessary and desirable characteristics of a CBDC in greater detail (chapter 3.1). We then consider different technical solutions (chapters 3.2–3.4). Finally, based on the necessary and desirable characteristics, we recommend one main solution and one alternative solution for further study (chapter 3.5).

## 3.1. Necessary and desirable characteristics

**Necessary characteristics**
Money in a Norwegian CBDC system must take the form of a **claim on Norges Bank**.

Any potential CBDC must be designed such that the CBDC has **value parity with bank money and cash**. Accordingly, supply- and/or demand-side mechanisms must be incorporated which ensure this.[10]

The CBDC must be **customer oriented**. In other words, it must be accessible to a broad public, and an infrastructure must be in place which renders the CBDC suitable for customer payments, including in terms of user-friendliness and security.

A customer focus contrasts with a so-called "wholesale" CBDC, where money is only accessible to banks and other financial institutions, much like central bank reserves at present. Internationally, there is discussion of whether a wholesale CBDC which is not account-based could offer advantages within the financial system, such as the possibility to effect quicker and more secure settlement between financial institutions. Such benefits are not discussed separately in the present report, although account is taken of the fact that some customer-oriented CBDCs could also play a role in settlement between financial institutions.

Steps should be taken to prevent a CBDC from contributing to financial instability, for example by intensifying a bank run. It will be necessary to integrate **frictions into transfers between the CBDC and bank money**, for example through interest rates, fees or quantitative limits. When necessary, formal and informal barriers can be used to limit the risk of rapid, large-scale substitution of bank money with a CBDC.

The CBDC must be **controlled by Norges Bank**. Irrespective of the operational model chosen, Norges Bank must be able to issue instructions on all aspects of the system.

The CBDC **must be capable of functioning as legal tender.** This requirement does not mean that the CBDC must necessarily be legal tender, but rather that its design must not include any inherent barriers to its potential functioning as legal tender.

The CBDC must be **compliant with obligations under EEA law**.

National legislation may have to be amended to permit the introduction of the CBDC. However, the system's design should not be such that unrealistic legislative changes

[10] Although there is currently value parity between bank money and cash, the possibility cannot be excluded that value parity may be broken in extreme situations, for example in the event of a bank run. In such circumstances, a CBDC could appear more attractive than bank money, and thus have a higher market value. However, we do not consider it necessary to give the consideration of value parity greater protection than is currently granted in the case of cash. Otherwise, the solution would eliminate all credit risk linked to bank money.

are required, for example heavy restrictions on data protection and consumer protection. A further necessary characteristics is that **payments in the CBDC must be settled with immediate and final effect** (finality).

The CBDC's design must be **consistent with sound IT architecture principles**. At the general level, this means requirements relating to scalability, accessibility, security, technological neutrality and adaptability. Guidance can be taken from the overarching IT architecture principles published by the Agency for Public Management and eGovernment (Difi).

A further requirement is that the CBDC must be designed to **satisfy requirements relating to technical autonomy**. The level of technical autonomy will depend on the need for the CBDC to function as an independent back-up solution. We have assumed that the CBDC must be independent of banks' electronic payment solutions.

In Norges Bank (2018), it was deemed sensible for **customer communications and due diligence to be undertaken by third parties**. Depending on the chosen design, these parties may be ones with which Norges Bank has concluded agreements or which have some other regulatory basis for performing the tasks. It is uncertain whether Norges Bank can delegate its responsibilities under other regulatory provisions, including financial regulations and data protection rules. Accordingly, it appears unrealistic to require third parties to assume full responsibility for customers. Nevertheless, it is desirable for such responsibility to be assigned to the third parties mandated to perform the tasks, wherever possible.

The necessary characteristics are therefore:

- claim on Norges Bank
- value parity with bank money and cash
- customer orientation
- adequate frictions in transfers between the CBDC and bank money
- controlled by Norges Bank
- capable of functioning as legal tender
- compliant with obligations under EEA law
- CBDC payments are immediate and final
- compliant with sound IT architecture principles
- satisfy requirements relating to technical autonomy
- customer communications and due diligence undertaken by third parties

**Desirable characteristics**
In addition to the necessary characteristics a CBDC must have, there may be various other characteristics a CBDC should have or which are desirable for a CBDC to have. A non-exhaustive list review of desirable characteristics follows below.

A CBDC should offer sufficient **flexibility to provide the desired degree of data protection**. Such data protection must, as a minimum, satisfy the requirements imposed by EEA law – a necessary characteristic. We do not consider it necessary for a CBDC to offer the same degree of anonymity as cash.

**Offline payment functionality** is desirable. Depending on the technical autonomy required, this may be a necessary characteristic, although the option to make offline payments is considered desirable in any event. Offline payment functionality can be implemented in various ways. It may be integrated into the solution, or the system can be designed to allow third-party stakeholders to deliver offline payment solutions on top of the CBDC.

It is desirable that a CBDC is capable of providing a **platform for third-party providers**. The objective is that third-party stakeholders should be able to innovate

and build services on top of the CBDC. These could include, for example, payment apps, solutions based on so-called smart contracts and offline solutions.

If it is possible to charge interest on a CBDC, the CBDC could serve as a **monetary policy instrument**.

Further, CBDC transactions can provide **information relevant** to Norges Bank's macroeconomic monitoring.

It is the characteristics of a CBDC which will determine the choice of technology, and it is not given that distributed ledger technology (DLT) will be the obvious choice. However, DLT may develop, and it may be sensible for the CBDC design to be sufficiently robust to allow this technology to be incorporated, i.e. for the CBDC to be **DLT compatible**. This could be ensured in several ways. One is for the CBDC system to be designed so that several "nodes" can be assigned functions, for example transaction validation, whilst keeping Norges Bank as the only current node. This could be termed "latent" DLT. Under this approach, decentralisation would have to be effected at the network level. Norges Bank would control the system rules (protocol level). A different approach is for the CBDC to be designed to permit third parties to add their own DLTs on top of the CBDC, or to permit integration with the DLTs of other stakeholders.

It is desirable for a CBDC to be in continuous use, at least to some degree. One way of achieving this is to make the CBDC an **attractive niche solution** for certain types of payment. Offering innovative payment solutions is not Norges Bank's primary task. A niche solution could be linked to Norges Bank's core operations, for example the provision of legal tender as a fall-back rule. Certain public payments could also be made using a CBDC. If the CBDC becomes an attractive platform for third-party providers, the market could foster the development of such niche solutions.

Some desirable characteristics are therefore:

- provision of the desired degree of data protection (beyond the requirements imposed by EEA law)
- offline payment functionality
- platform for third-party providers
- monetary policy instrument
- provision of information relevant to Norges Bank's macroeconomic monitoring
- DLT compatibility
- attractive niche solution

## 3.2. Token-based and account-based solutions

In Norges Bank (2018), a distinction was made between account-based solutions, value-based solutions and hybrid solutions. Value-based solutions entail local storage of money, for example on payment cards or in mobile apps. A hybrid solution allows value to be linked to a register without the registered information necessarily being associated with a name.

In CPMI (2018), a distinction was made between token-based money and account-based money. Token-based money includes value-based solutions and hybrid solutions. CPMI (2018) states:

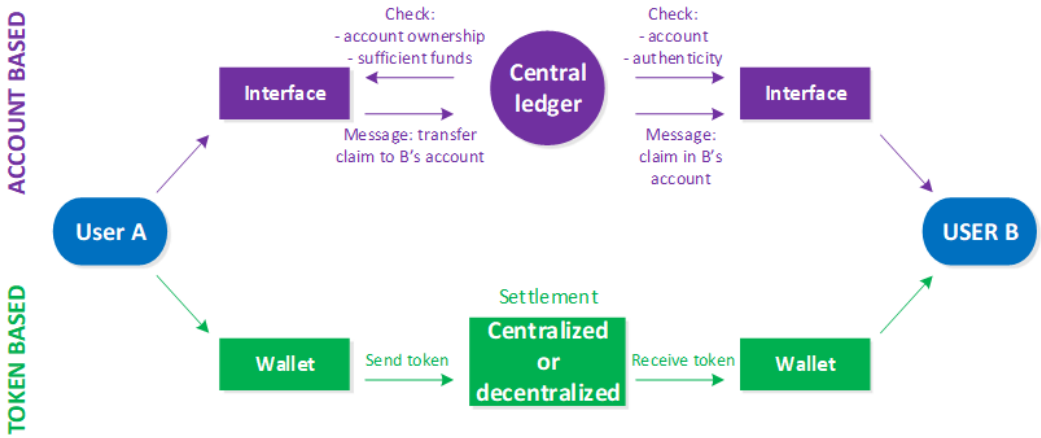
"*A key distinction between token- and account-based money is the form of verification needed when it is exchanged (Kahn and Roberds (2009)). Token-based money (or payment systems) rely critically on the ability of the payee to verify the validity of the payment object. With cash the worry is counterfeiting, while in the digital world the*

*worry is whether the token or "coin" is genuine or not (electronic counterfeiting) and whether it has already been spent. By contrast, systems based on account money depend fundamentally on the ability to verify the identity of the account holder. A key concern is identity theft, which allows perpetrators to transfer or withdraw money from accounts without permission. Identification is needed to correctly link payers and payees and to ascertain their respective account histories."*

In the case of token-based money, value is represented directly by the token. Cash is a good example of token-based money, as it is the genuineness of cash, not the identity of the payer, which is critical for the payee. Payment with token-based money requires the payee to check that received money is genuine. Any electronic alternative must include security mechanisms which block the making of multiple payments with the same money at the same time (no double-spending).

In the case of account-based money, value is linked to the credit balance of an account belonging to an identifiable account holder. When payments are made with account-based money, the holder must be identified and it must be verified that the payer has the money which is to be used (coverage) and transferred to the payee; see Figure 1.

**Figure 1. Account-based and token-based CBDCs. Fundamental mechanisms**




Source: IMF (2018)

In the present report, we have applied the distinction made between token-based and account-based money in CPMI (2018), and classify different solutions as token-based and account-based solutions.

Below, various token-based and account-based solutions are presented in general terms. We start with existing, tested solutions, and thereafter consider opportunities for broader use of the technology beyond existing solutions.

## 3.3. Token-based solutions

We have considered two types of token-based solution:

- **Storage on physical devices** generally entails the storage of money locally, on a physical device (card, mobile telephone or other mobile device with internet access).
- **Register-based solutions** safeguard the integrity of money by means of an underlying register, meaning that money does not need to be linked to a specific physical device.

**Storage on physical devices**

In a token-based model involving storage on a physical device, value is stored locally on an electronic device, for example a pre-paid card or a mobile telephone (either on the sim card or in the actual mobile telephone). Payments are effected through a transfer of funds between the payer and payee's electronic devices, without verification of the payment by a third party. The integrity of the value is ensured by cryptographic technology integrated into the user equipment.

In such a system, card and mobile payments are made by contact with or physical proximity to a terminal or card reader. These payments require proximity between the payer and payee.

Payments in systems based on storage on physical devices are settled immediately, and are final. As payments are received, a payee will accrue receivables from the system owner until the payments are forwarded for settlement and crediting in an account-based system (operated by a central bank or private bank).

Payers do not have to identify themselves when making payments through such a system, but all individual payments can potentially be registered to the cards or chips used and be consolidated into a register in connection with topping-up and withdrawals. A greater degree of anonymity can be secured by making topping-up payments and withdrawals in cash.

In similar systems which are currently in use, topping-up and withdrawals are made using a mobile telephone or at user locations. Funds can be transferred from a bank account into an e-money account administered by the system owner. E-money can then be used for online shopping or to top-up the chip in the mobile telephone or a physical card.

If the electronic device is lost or destroyed, the money on the device will in principle be lost. Accordingly, it is likely that there will be limits to how much value users wish to store on such devices. Moreover, individual system owners may set quantitative limits on value storage on individual devices. When value is only stored locally, it will not be possible to pay interest on it. These characteristics may limit the volume of value transferred from bank deposits to the CBDC.

**Register-based solutions**

A challenge presented by electronically stored token-based money is that money can be copied and used multiple times (double-spending). As stated above, when value is stored on a device, the security of the physical equipment (hardware) hinders such double use.

An alternative is to establish a register which continually records transactions and prevents double use of the same money. This would entail checking each transaction against a register to ensure that the money in question has not been used previously. Unlike a bank account, this register would not be associated with a particular identity, but rather with cryptographic codes and keys.

Users could control such a CBDC via a user interface which communicates with the register, for example a mobile app. Since the money would be linked to the register and the user interface would only be used to access the money, users who lose their user equipment would not lose their money. However, the opportunity to use the money may be lost if the information required to use it is only stored on the user equipment.

While this principle is integrated into most crypto-currencies, the concept of "digital cash" was developed as early as the 1980s, not least in the wake of innovations in the

field of cryptography.[11] In the literature, many authors have argued that register-based token money is suitable for CBDC use.[12] The technology used in such solutions is further explained in the box below.

## Box: How do register-based solutions work?

**Key-based transactions**
Control of a token is linked to cryptographic keys, i.e. lengthy digital codes. To transfer the value represented by the token, access is required to a private (secret) key. Each private key can be linked with a public key. The public key can be published because it is considered impossible to invert the public key to reveal the private key. The token is a digital code/address in a register and represents a given value. The adress is derived from the user's public key.[13]

A transfer is effected through the payer's "signature" of the transaction using his or her private key. The transaction is only valid if the digital signature matches the token address. This public key can be used to verify that the token has been transferred by the person in possession of the private key associated with the token. In practice, such long code keys will be protected by a password, biometrics or other authentication solutions in the user interface used to make transfers.

**The register validates transactions**
The register is designed to prevent the value represented by the token from being used several times, i.e. the register validates valid transactions and rejects invalid transactions. A token can be represented in a register in several ways:

- A token can take the form of an account, where consolidated value is registered against the token.[14]
- An alternative is for the register to review all transactions and check whether the token has been topped up with sufficient value to cover the intended payment, i.e. that enough has been paid in to cover what is to be paid out.[15]
- A third alternative is for a token to be deleted from the system once it has been used and for a new token to be created for the payee. This solution is used, for example, by the DigiCash solution.[16]

Transfer by means of cryptographic keys makes it easy to supplement transaction execution with programming functions. This allows a range of conditions to be imposed on token transfers, for example that several persons must sign using their private keys to effect a transfer (so-called "multi-signature").

**Smart contracts**
A further example in this context is that different transfers can be made inter-dependent. If, for example, securities are recorded in the same register or a compatible register, the release of money can be made conditional on simultaneous release of securities (DvP). Payments can also be made conditional on the delivery of goods, provided that a mechanism exists for recording such events in the register. Conditional transfers can be combined with a lock-in of the sum in question ("escrow") and a time limit, thus ensuring that a locked-in payment will be returned to the payer if certain conditions are not met by a specified time. Such conditional transactions which

[11] See Narayanan et al. (2016) and Sojli and Furche (2018).
[12] See for example Wandhöfer (2017).
[13] Technically, this will often be a "hash code" generated by the public key.
[14] Used by the crypto-currency Ethereum.
[15] Used by Bitcoin.
[16] See Narayanan et al. (2016).

are executed automatically by a register on the basis of pre-defined instructions are often referred to as smart contracts.

**DLT**
The traditional solution is for a register to be managed by a central administrator in whom users have confidence. An innovation facilitated by crypto-currencies is that registers can be managed using decentralised technology (DLT).[17] In such systems, registers are not administered by a central third party in whom users have confidence. Instead, validation is carried out by nodes/users of the network in whom users do not necessarily have confidence. Open networks like crypto-currencies often allow any user to carry out validation, whereas closed systems may employ appointed validators (thus potentially reducing resource use considerably).[18] Incentive mechanisms are intended to ensure confidence in a system featuring validators in whom users do not necessarily have confidence.[19] It is not given that the register for a token-based solution must be DLT-based.

**Integration with other solutions**
Through the use of smart contracts, register-based token money can be combined with other registers which are separate from the CBDC register. For example, it could be the case that some stakeholders wish to develop a DLT solution which uses a CBDC for transactions. To avert credit risk, the CBDC could be locked-in to the CBDC register by means of a smart contract, and be replaced by a token in this register. Net settlement could then be effected at regular intervals using the CBDC. The person operating the DLT register would never be in a position to dispose of the locked-in funds. Likewise, third parties might wish to provide offline-based payment solutions without exposing users to credit risk linked to the company that offers such solutions. A third area of application is payments between devices connected to the internet of things (IoT).

## 3.4. Account-based solutions

Two primary alternatives appear feasible for an account-based solution:

- An open account solution corresponding to payment accounts offered by private banks, with the possibility of direct payment to recipients' private bank accounts.
- A closed account solution which requires both the payer and the payee to have an account with Norges Bank. The solution will have similarities with proprietary account solutions offered by e-money institutions.

**Open account solution**
In a bank account-based solution, users would have a traditional bank account with Norges Bank or an operator supervised by Norges Bank. Payments to payees with accounts in other banks would be implemented in the customary manner, through the ordinary payment system. To use deposit money for customer-focused payments, payment instruments would have to be issued to users, and Norges Bank would have to participate in relevant payment systems, including inter-bank systems and systems for payment services. Depending on the organisational structure, the solution would have strong similarities with a full-reserve bank.

[17] Although the focus is often primarily on DLT technology with respect to register-based solutions for token money, the means of effecting transfers are probably an equally important element; see Halaburda (2017).
[18] This is frequently used in private blockchain solutions, such as R3's Corda solution.
[19] Such incentives typically inflict costs on the validator in connection with validation and receipt of financial compensation for validation (transaction fees and newly issued units of a crypto-currency). Provided that a sufficiently large proportion of other validators have incentives to validate correctly, the reward will be lost in the event of an invalid validation.

**Closed account solution**
A closed account solution has similarities with account solutions offered by e-money institutions such as PayPal. Such e-money accounts have differing interfaces with the bank-based payment system. Nevertheless, the key characteristic of electronic e-money solutions is that both the payer and the payee have an account with an e-money institution which contains money issued by the e-money institution. The payer normally tops up this account with bank money, in return for which the e-money institution issues a corresponding amount of e-money to the customer. When the solution is used to make a payment, settlement occurs through debiting and crediting of the payer and payee's respective accounts in the system operated by the e-money institution. If they wish, users can exchange their e-money for bank money.

A CBDC could be organised as e-money-like system in which payments require the payer and payee to have accounts in the system. Payments through the system would then be independent of the bank payment system and bank payment instruments.

A closed account solution can also be referred to as an "account-based solution with restrictions". It can be designed to be expandable into an open account solution.

As discussed above, a closed account solution based on the principles of e-money can be combined with storage on physical devices.

## 3.5. Solutions recommended for further consideration

The working group has evaluated the different solutions by reference to necessary and desirable characteristics.

We have not found any solutions which have to be excluded because they clearly fail to fulfil necessary characteristics. However, the different solutions safeguard the necessary characteristics to differing degrees. Moreover, they also vary quite considerably in terms of fulfilling the desirable characteristics.

If the only purpose of a CBDC is to introduce a basic electronic supplement to cash within a reasonable period of time, a solution based on **physical-device storage only** appears the most appropriate. Relatively well-tested technology and infrastructure can be used. The disadvantage is that the solution will be "too similar" to cash, and usage will probably be low for several of the same reasons as are driving low and falling cash usage. Accordingly, even though such a solution would have many of the same characteristics as cash, it would be unlikely to ensure retention of the characteristics of cash. A further disadvantage is that the system would impose high administrative costs on Norges Bank or the party mandated to operate the solution.

Realisation of a **register-based solution** would require more development, and would therefore take longer and entail higher development costs. Nonetheless, this appears to be a solution which is more robust in the face of future developments and future needs. It could offer the required characteristics, and has potential to be sufficiently attractive to safeguard important characteristics of cash. The solution could also function as a platform for innovation through third-party solutions, would facilitate smart contracts which could be a useful addition to the payment system, and could be used as a monetary policy instrument. The solution could be designed to function as a technically independent back-up solution.

An **open account solution** would have to be integrated with bank payment solutions, and would be a close substitute for accounts with private banks, subject to the exception that no credit would be on offer. With this solution, demand would have to be managed through interest rates and other conditions. However, in a crisis users may wish to use the account as a secure store of value. An open account solution would be an integral element of bank payment solutions, and it would be difficult to maintain this inter-operability while also satisfying the requirement of technical

autonomy. Nevertheless, provided that independent payment instruments are available, it would be possible to transfer money between two persons with accounts in the same solution independently of bank solutions. With an open account solution, it would also be possible for payees to receive money from persons with a CBDC account without having a CBDC account themselves. This could undermine incentives to open a CBDC account, which in turn could negatively impact the back-up solution.

A **closed account solution** would be a weaker substitute for bank money than an open account solution. In payment situations, the account could only be used for payments between persons who have an account with Norges Bank. In a crisis, the solution could probably be used as a store of value. In a closed solution, however, it would probably be easier to use instruments other than interest rates to prevent large transfers out of bank accounts, for example by imposing quantitative limits on transfers into e-money accounts, or on e-money account balances. The solution could be designed to be independent of bank payment infrastructure in payment situations. The solution could easily be combined with a solution permitting local storage on a physical device, meaning that the solution would also allow decentralised, offline use. The solution would be sufficiently independent of bank account systems, and thus provide a platform for third-party innovation. An open account solution, on the other hand, would have to take greater account of EEA rules on payment accounts, including with respect to solutions granting third parties access. Freedom of design would also make it easier to develop niche solutions which could ensure a certain degree of use.

Based on the above considerations and the findings in Norges Bank (2018), we recommend that further work be done on:

- A CBDC in the form of register-based token money (main solution)
- A CBDC in the form of a closed account solution offering the option of storage on physical devices (alternative solution)

Accordingly, we are currently not recommending further exploration of a system based solely on the storage of money on physical devices, or of an open account solution. However, in choosing the design for the alternative solution, we have emphasised that the solution can be expanded into an open solution. A summary of the different solutions is provided in Table 1. We would emphasise that the conclusions are uncertain and may change over time as payment system structures evolve and new knowledge is gained.

**Table 1: Evaluation of the different solutions**

| Evaluated solution | | Advantages | Disadvantages |
|---|---|---|---|
| Register-based solution<br><br>(main solution) | T* | • Possibility for precise specifications reflecting characteristics<br><br>• Robust with respect to future needs (smart contracts, DLT-compatibility, platform for innovation)<br><br>• Complements bank money<br><br>• Scope for offline payments (back-up solution) | • Extensive development required<br><br>• Uncertainty about adequate frictions between the CBDC and bank money |
| Closed account solution offering storage on physical devices<br><br>(alternative solution) | A*<br><br>(T) | • Clearly distinguishable from ordinary bank accounts<br><br>• Strong control<br><br>• Imperfect substitute for bank money – customers also required to have a bank account<br><br>• Offline payments incorporated (back-up solution)<br><br>• Can be expanded into an open account solution | • High operating costs – an entity must be established to provide customer services<br><br>• Supplier dependence |
| Storage on physical devices | T | • Decentralised, like cash<br><br>• Transactions are always offline (back-up solution)<br><br>• Frictions between the CBDC and bank money like those associated with cash | • Little to indicate that the solution will become more attractive than cash<br><br>• Cannot be used for distance payments<br><br>• Supplier dependence |
| Open account solution | A | • Can be used seamlessly with an ordinary bank account | • Little control over volume and customer solutions<br><br>• Dependence on banking systems<br><br>• Offline corresponding to the solution offered by banks |

*) T: Token-based. A: Account-based.
Source: Norges Bank

# 4. Organisation and implementation of the solutions

## 4.1. Organisation[20]

In the case of **the main solution**, Norges Bank or an entity controlled by Norges Bank will in principle have to develop a protocol/rules for the register, issue money and operate the register. Consideration could be given to designing the solution to incorporate "latent" DLT, to allow other parties to perform certain register tasks in future or when otherwise necessary. This could include, for example, validation of transactions. We envisage that the tokens in the register would be distributed via banks, and potentially other stakeholders who contract with Norges Bank. Banks (and possibly other parties) who sell tokens to customers and provide user interfaces will be in contact with end users. A material pre-condition for a token-based solution is that Norges Bank does not maintain a register which links token ownership with identity. (Otherwise, the solution would in practice be an account-based solution offered by Norges Bank.)

The **alternative solution** must be operated by Norges Bank or an entity controlled by Norges Bank.[21] This entity could either operate the solution itself or appoint private stakeholders who are granted access to accounts through API[22]-solutions based on the same principles as PSD2. In this solution, a large proportion of customer contact could be left to private enterprises. Nevertheless, it is uncertain whether Norges Bank or the entity operating the register could avoid all contact with individual customers in its capacity as account provider. A further question is whether Norges Bank should in any event offer a "minimum solution" in the market to avoid dependence on private stakeholders.

## 4.2. Conditions of use

Both the main solution and the alternative solution can be organised so that the requirements for accessing the CBDC are largely the same as those which currently apply for accessing an account with a Norwegian bank. In the case of the main solution, this could be done directly by making procurement of the CBDC conditional on the holding of an account with a Norwegian bank. In the alternative solution, the best solution would probably be to establish an undertaking controlled by Norges Bank which grants customers access to accounts subject to the same requirements as apply to open an account with a Norwegian bank (know-your-customer and anti-money laundering procedures, etc.) The solutions could be designed to ensure that transactions are only possible between persons who have completed the approval process described above. This would prevent the Norwegian CBDC from playing a significant role as money for persons with no links with Norway.

With respect to both the main solution and the alternative solution, consideration could be given to whether it should be possible to grant limited access to persons who do

[20] See Lagarde (2018) for a discussion of the scope for partnerships between private parties and central banks.
[21] It may be possible for the register underpinning this solution to be operated on a decentralised basis. In view of current technology, however, DLT appears to be the most relevant option for the token-based solution.
[22] "Application Programming Interface" – a software interface.

not satisfy the requirements mentioned above, for example tourists and other persons who are in Norway temporarily. Both solutions could permit this.[23]

## 4.3. Conversion into bank money

Regarding the **main solution**, the most practical approach would be for customers to acquire token money pursuant to the same principles as currently apply to the procurement of cash, i.e. through banks. Consideration could be given to whether other entities, such as e-money institutions, should be assigned such a role as well. In practice, this could be achieved through Norges Bank selling token money to banks, who could set up register addresses for this money for their own customers. This will be discussed further below, in the context of choice of technology.

As regards the **alternative solution**, the most practical approach would be for customers to convert money into the CBDC e-money in the same way as currently applies to e-money, i.e. by making a transfer directly from a bank account or using a debit or credit card. Settlement between banks and the CBDC provider would occur through their respective central bank accounts.

## 4.4. Restricting large drops in demand for bank deposits

The **main solution** may present challenges linked to the avoidance of large drops in demand for bank money. Cash features an inherent limit, in that it can be lost or otherwise nullified. A question which arises in this context is whether corresponding restrictions would apply to register-based token money.

If tokens can be stored relatively securely in storage solutions, there may be fewer frictions than in the case of cash. An example is storage of access codes in a secure data centre run by private stakeholders (so-called “cold storage”). This storage system is currently used by owners of crypto-assets.

Storing cryptographic codes securely in cold storage is costly. In addition to direct costs and the need for confidence in the relevant private stakeholders, administrative costs will be incurred in connection with the handling of inheritance cases, etc. It may appear rational to accept all of these costs linked to crypto-currencies when the plan is to hold these for a long time in the expectation that their value will rise, but doing so appears less attractive in the case of a CBDC with a relatively stable value. A cost-benefit analysis suggests that there are probably better alternatives that could function as a store of value.

Further, individuals could be threatened into surrendering codes, etc. At worst, this could entail the loss of one’s entire possessions, a possibility the banking system protects against, at least in part. To avoid this in the case of a register-based CBDC, it would be necessary to construct similarities with the banking system.

In a register-based system, it would be possible to set interest rates (including negative rates) and adjust transaction fees. These measures could constitute instruments for restricting dramatic changes in demand for bank money. Quantitative restrictions could threaten value parity with bank money.

[23] For example, use of such a limited solution could be restricted to smaller sums or a limited time period, and be made subject to the requirement that at least one party to a transaction must have completed full customer due diligence (so that transactions are not possible between two persons with limited access). One questions which arises is how such persons would access the CBDC. The solution could be to permit the use of foreign deposit money/credit cards and/or cash.

The **alternative solution** would be a weaker substitute for bank money than an open, comprehensive, bank account-based solution. In a payment situation, the account could only be used for payments between persons with an account in the CBDC system. In practice, a customer would have to have both a bank account and a CBDC account to be able to make a full range of payments (including, for example, purchases from abroad), and to be able to use bank-issued debit cards.

In a crisis, the account solution could become an attractive store of value. In a closed solution, it would be easier to use other instruments in addition to interest rates to block large transfers out of banks, for example by imposing limits on the size of transfers into CBDC accounts, and on balances held in CBDC accounts. Further investigation is required of whether quantitative limits on CBDC accounts could threaten value parity between the CBDC and bank money. In view of the deposit guarantee scheme and other measures to protect bank money, it appears likely that a CBDC would be unattractive as a store-of-value solution, although it could be attractive as a back-up solution for payments while a customer is waiting for access to money protected by the deposit guarantee scheme.

## 4.5. User interface and third-party access

As regards the **main solution**, we have assumed that Norges Bank would be responsible for administering the register, and that it would enter into "wholesale customer contracts" with banks (or other stakeholders) authorised to sell tokens to their customers. The system could be organised so that any person or authorised stakeholder can create a user interface to facilitate spending of the CBDC, including solutions for stores and other businesses. Further, the system could be designed to allow third parties to provide different solutions based on smart contracts, DLT, IoT payments, offline payments, etc.

In principle, the **alternative solution** would be a closed solution offered by Norges Bank or an entity controlled by Norges Bank. Stores and sales outlets could sign up to the solution and, if they wish, provide terminals for the use of physically stored money. Using APIs compliant with PSD2 principles, third parties could develop solutions for consumers and businesses, and competition linked to the supply of terminal infrastructure could be facilitated. Accordingly, businesses could offer their own solutions and user interfaces for using the CBDC.

## 4.6. Independent back-up solution

The **main solution** would allow register-based token money to function independently of bank payment systems. The CBDC would comprise an independent register which is validated and updated without the involvement of bank solutions. However, users would be dependent on banks or other third parties to acquire money. Users who use a bank user interface to access the CBDC could be affected if banking systems were to fail. Nonetheless, systems could be designed to allow users to access registered CBDC holdings independently of specific stakeholder interfaces.

As stated above, a system of register-based token money would in principle require users to have internet access (i.e. to be online), and would require Norges Bank's validation system to be operational. However, it would be possible to develop third-party solutions on top of the system, which could meet these requirements – at least for some time – for example through offline solutions like DLT systems running alongside the CBDC register. Such solutions would allow execution of transactions involving a CBDC or CBDC-based tokens without continuous access to the register, and without creating credit risk for the undertaking providing the solution. This could be achieved by, for example, implementing a time-limited lock-in of a specified amount in the register for use in the solution, and subsequent consolidation with the register. Only a person able to present cryptographically valid codes could effect a transfer of money from the amount reserved in the register. Based on this principle, hardware-

based solutions or “scratch card”-like solutions could be developed to facilitate CBDC payments in an offline situation.

In the **alternative solution**, storage on physical devices would permit decentralised settlement, making users independent of banks in payment situations. Reliance on an internet connection would also be eliminated. As in the main solution, users would be dependent on banks or other stakeholders to acquire the CBDC.

## 4.7. Available technology and development needs

In the case of the **main solution**, further consideration is required of how register addresses should represent money. As stated above, various alternatives are available for representing money in registers, and there is no basis for making firm recommendations at this time. The choice of technology will also depend on how necessary or desirable characteristics are to be safeguarded, including data protection, smart contracts, DLT compatibility, etc.

Considerable development work will have to be done before a register-based solution can safeguard necessary and desirable characteristics. Achievement of the solution therefore lies some way in the future. Norges Bank will either have to assume a significant development/promotional role or wait for the market to develop relevant solutions. The register-based solution will largely be based on the achievement of characteristics through market-based third-party solutions (for example solutions for offline payments). There is no guarantee that the market will supply such solutions on the desired scale. In such case Norges Bank may have to supplement the market, for example by subsidising stakeholders wishing to develop such solutions.

As regards the **alternative solution**, solutions are already available in the market, for example the Octopus system used in Hong Kong. It would therefore be possible to procure a relatively complete solution. One disadvantage of purchasing a finished solution is that it may create strong dependence on an individual supplier. It may therefore be necessary to engage in some in-house development to avoid such reliance.

# 5. Legal matters

## 5.1. Regulatory framework for Norges Bank in connection with the provision of relevant services

Norges Bank (2018) contains an assessment of the rules applicable to Norges Bank in the provision of a CBDC. The evaluation below is largely based on the assessments in the previous report.

Norges Bank's operations are governed by the **Norges Bank Act**. The Storting (the Norwegian parliament) has adopted a new Norges Bank Act, which forms the basis for the following discussion.[24] Pursuant to section 1-3(1) of the new act, Norges Bank is to "be the executive and advisory body for monetary policy". Pursuant to section 1-3(3) of the new act, the bank is to "issue banknotes and coins, facilitate the central settlement system and monitor the payment system". Both the main model and the alternative model have been selected with achievement of these purposes in mind. Both provisions were also included in the old Norges Bank Act.

In accordance with the old Norges Bank Act, section 1-3(6) of the new Norges Bank Act provides that, "Norges Bank may additionally implement any measures customarily or ordinarily taken by a central bank". In principle, introducing any of the outlined solutions would not be contrary to this provision. If Norges Bank were to decide to issue a CBDC, this would be because it considers doing so an ordinary central bank task. Nevertheless, introducing a CBDC is a far-reaching and complicated step. While the new Norges Bank Act does not regulate CBDCs, the question of introducing a CBDC was discussed in Prop. 97 L (2018-2019), which states, on page 104:

"*The ministry agrees with the Norges Bank Act committee and Norges Bank's Executive Board that any introduction of electronic central bank money for the public requires further investigation, including of the consequences for banks and credit provision, and that the Norges Bank Act should not facilitate this at the present time.*"

Norges Bank (2018) contained an assessment of the financial regulatory requirements which would apply to Norges Bank in connection with the supply of a CBDC. As regards compliance with know-your-customer and anti-money laundering rules, Norges Bank could largely rely on third parties to do this work. In the **main solution**, compliance could generally be based on the procedures of banks and other stakeholders authorised to sell tokens to end users. Necessary compliance procedures would be a prerequisite for performance of this task. In the **alternative solution**, Norges Bank or the entity operating the solution would have less scope for transferring all compliance to third parties. Even though the solution would be based exclusively on APIs and user interfaces supplied by third parties, Norges Bank would still be the account provider.

Consideration must also be given to which parts of the regulatory framework for payments Norges Bank will be subject to in connection with the supply of a CBDC. Norway's implementation of the revised Payment Services Directive (PSD2) and e-money rules is of particular relevance. Both regulatory instruments contain wide-ranging exemptions for central banks acting in their capacity as monetary authorities. Supply of central bank money can probably be regarded as such a function, meaning that PSD2 and the e-money rules will not impose significant restrictions on a CBDC under any of the proposed models. In the **main solution**, the token-based money will

[24] See Prop. 97 L (2018-2019) and Innst 338 L (2018-19). The act was approved by the King in Council on 21 June 2019. The majority of the act enters into force on 1 January 2020.

not constitute a payment account, making it unlikely that requirements to grant third-party stakeholders access will have to comply with PSD2. The same applies to the **alternative solution**, as the proposed solution is a closed system with a limited area of application.

Both solutions will in principle fall within the legal definition of e-money in section 2-4(2), first sentence, of the Financial Institutions Act:

"*By electronic money is meant an electronically stored monetary value represented by a claim on the issuer that is issued on receipt of funds for the purpose of making payment transactions and that is recognised as a means of payment by entities other than the issuer*."

Accordingly, if supplying a CBDC is not deemed to be an official function, a detailed assessment will be required of adjustments necessitated by the e-money rules.

Supply of a CBDC must comply with data protection rules. Responsibility cannot be outsourced. In the **main solution**, Norges Bank or any entity which operates the CBDC will not have to process significant volumes of personal data. The CBDC will be issued to banks or other stakeholders authorised to circulate the CBDC, and it will be these entities that process personal data in connection with this task. In the **alternative solution**, Norges Bank or an entity controlled by Norges Bank will necessarily have to link identities with accounts, and will receive information about transactions which have to be implemented. This may impose extensive responsibilities pursuant to the data protection rules.

If a CBDC is introduced, it will play a fairly central role in the payment system, and one of its purposes will be to foster competition within the payment system. However, the EEA Agreement and competition rules may impose restrictions intended to prevent the CBDC from limiting or unnecessarily distorting competition. Accordingly, Norge Bank should not adopt conditions for third-party access to the system which result in unnecessary distortion of competition or are particularly advantageous to individual stakeholders.

## 5.2. Necessary amendments to the Norges Bank Act

If the legislature considers that Norges Bank should have a duty to issue a CBDC, the Norges Bank Act will have to be amended accordingly. If the CBDC is to be legal tender the act will also have to be adjusted to facilitate this; see section 3-5 of the new act. If the CBDC is deemed to constitute deposits with Norges Bank, this will also requirement amendment of the Norges Bank Act, see section 3-1 of the new act, which generally limits deposit rights to banks and undertakings in the financial sector. At this juncture, we will only discuss the latter issue in more detail.

In the **main solution**, the token in the register will constitute a claim on Norges Bank. In legal terms, such claims can be compared to cash, and will therefore not be regarded as deposits with Norges Bank. Thus, the solution will not necessitate amendment of the Norges Bank Act's provisions on who may deposit funds with Norges Bank.

The **alternative solution** rests on the same principles as current account-based e-money solutions. From a legal perspective, e-money entails issuance of money by an e-money institution which has the users as its customers. Customers control accounts operated by the institution. E-money payments are made to and from accounts in the system operated by the e-money institution. An e-money-based CBDC solution would require Norges Bank to act as an e-money institution, either directly or indirectly, and for CBDC payments to take the form of account transfers in Norges Bank's system. Such payments/account transfers would occur outside of banks' ordinary payment systems.

In principle, such a CBDC solution would fall within the legal definition of e-money, as discussed above. The question is whether, in the alternative solution, the CBDC would constitute a deposit pursuant to section 3-1 of the new Norges Bank Act. There is no general legal definition of "deposit", but a deposit must generally be regarded as a claim by a depositor on the party that accepts the deposit. The size of the claim will typically vary in line with withdrawals from and further deposits into the original deposit account. This description of a traditional deposit with a bank or other financial institution can be distinguished from the closed account system operated by e-money institutions. Section 2-2 of the Financial Institutions Act states expressly that

"*Means of payment that are accepted in order to issue electronic money are not deemed to be deposits from an unrestricted range of depositors. The same applies to means of payment accepted by payment institutions or electronic money institutions in connection with payment service assignments.*"

In other words, pursuant to the E-Money Directive, the legislation thus expressly distinguishes between ordinary deposits and receipt of funds for the purpose of issuing e-money. Fundamentally, it is logical to apply this distinction when interpreting section 3-1 of the new Norges Bank Act, i.e. to conclude that an e-money-based CBDC solution does not conflict with restriction of the deposit rights of undertakings in the financial sector.

Purpose considerations also suggest that this interpretation is correct. The situation which section 3-1 aims to regulate is where private individuals and legal persons other than banks and undertakings in the financial sector wish to make deposits into accounts at Norges Bank, in competition with other banks. This is significantly different from the introduction of an e-money-based CBDC solution by Norges Bank, which would be a distinct system independent of banks' ordinary payment systems.

The conclusion is that neither the main solution (token with register) nor the alternative solution (closed account solution) requires amendment of the Norges Bank Act's provisions on who may deposit money with Norges Bank. As stated in section 5.1, however, introducing a CBDC may necessitate legislative amendments due to its potential far-reaching effects.

## 5.3. Need for other regulatory amendments

The introduction of a CBDC may necessitate various legislative amendments to ensure that the CBDC functions as intended. This can be effected through a separate CBDC act and/or through adjustments to the current regulatory framework, particularly the financial regulatory rules. Some of the need could also be met by applying licensing requirements and similar conditions to stakeholders involved in CBDC distribution.

This report does not include an assessment of the best legal approach to implementing regulatory amendments. However, we would note that if the alternative solution is chosen and a separate entity controlled by Norges Bank is established to supply the CBDC to the public, a separate legal framework may be required in relation to this entity.

It may be necessary to make legislative amendments to ensure circulation of the CBDC. In this connection, it may be appropriate to require banks and, if relevant, other institutions to supply the CBDC to customers on the same terms as cash is currently supplied. It may also be necessary to impose additional obligations on banks in connection with sale of the CBDC to the public. There may be a need for supplementation of the know-your-customer rules and anti-money laundering rules to ensure adjustment to the existence of the CBDC. A further potential need is for special security rules applicable to relevant institutions, to ensure that the CBDC is a secure alternative for users.

If a CBDC is to become legal tender, it may be appropriate to introduce provisions similar to those currently found in section 38(3) of the Financial Contracts Act on the right to make payment in cash, to ensure that customers can pay with the CBDC at all user locations.

It may also be necessary to regulate third-party suppliers of CBDC-related services other than the sale of CBDC to the public. This will typically include providers of digital wallets and other user interfaces. We assume that it will be attractive to supply solutions which facilitate easy CBDC use and which allow customers to integrated CBDC use and storage with other services. Examples include Vipps, Apply Pay, Google Pay and various PSD2 stakeholders. If such entities do not offer secure CBDC solutions, confidence in the CBDC may be undermined and reputational risk may arise. Typical regulations in this context include requirements as to authentication mechanisms and back-up solutions. In the case of register-based solutions in which stakeholders offer access by password, biometrics, artificial intelligence, etc., it may particularly important to impose requirements as to the security of these mechanisms, and requirements regarding back-up solutions.

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