E-krona report

E-krona pilot, phase 3

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SVERIGES RIKSBANK

List of contents

Glossary

API: Abbreviation for *Application Programmable Interface,* which is a specification of how different computer programmes can communicate with each other.

Blockchain: Intertwining of blocks containing verified transactions. The chain enables traceability of transactions, which verifies their authenticity.

CBDC: Abbreviation for *Central Bank Digital Currency*, A digital form of central bank money.

Conditional payment: A payment that is only made if a specific condition is met.

Conditional money: Money that can only be used for certain predefined purposes or in certain predefined time periods.

Corda: DLT platform on which the e-krona pilot test network is built.

DLT (Distributed Ledger Technology)*:* Distributed storage of information, such as transactions, spread among participants in a network instead of being stored in a central location. Members of the network can usually read and, depending on authorisation, add information.

DvP (delivery versus payment): A payment solution that ensures that a payment can only be made if a delivery of something else is also made.

E-krona: A Swedish CBDC available to the public.

E-krona network: A network consisting of the Riksbank and authorised participants in which the e-krona is distributed and used in transactions. The network is built on a DLT platform called Corda.

Foreign Exchange (FX) providers: A term used in Icebreaker for participants authorised to hold CBDCs in multiple currencies and CBDC networks. FX providers make it possible for end users to send payments between the CBDC networks in the project.

Foreign Exchange (FX) service: Exchange of money between two currencies.

HTLC: Short for *Hash Time Lock Contract*, which is a form of smart contract that locks money and is used to reduce counterparty risk by ensuring that a payment can only be unlocked with a cryptographic password. It can be used for conditional payments, for example.

Hub: In Icebreaker, a nationally independent point that allows different CBDC networks to communicate with each other. The hub determines the standard of communication and transmits messages between the different CBDC networks.

Participant: An actor entitled to participate in an e-krona solution, such as a payment service provider, and to provide services to the public, such as acquiring, holding and executing e-krona payments.

Payment scheme: A set of rules for payment transactions executed via a specific payment instrument, such as direct debit.

Payment system: The system in which payment transactions are executed and the rules governing the relationship between the participants in that payment system

PvP (payment versus payment): A payment solution that ensures that a payment can only be made if another payment is also made.

Smart contract: Code on a blockchain that is executed when predefined conditions, for example for money or payment, have been met.

Token: Within the e-krona pilot, a uniquely identifiable digital unit of value with the property that it can carry the value of Swedish kronor.

Use cases: Descriptions of how an e-krona solution will interact with its environment and the scenarios that need to be supported, such as payments between individuals.

1 Summary

In the third phase of the Riksbank's e-krona pilot project, work continued on the technical tests of the DLT and blockchain solution on which the e-krona pilot is based. The aim of the pilot project is for the Riksbank to increase its knowledge of a central bank-issued digital krona. There is currently no decision on issuing an e-krona, how an e-krona might be designed or what technology might be used.

The starting point of the e-krona pilot has been for the Riksbank to collaborate with payment service providers to ensure that the general public has access to the e-krona. During the third phase of the e-krona pilot, the Riksbank has therefore investigated how collaboration can be designed on the basis of existing models for collaboration on instant payments and the distribution of central bank money in electronic form to the general public. These models have been used as a starting point to increase understanding of how the central bank and the actors involved in connection with the issuance, distribution and usage of an e-krona can collaborate. Collaboration includes the design of participation conditions, management organisation, regulatory framework (including brand management, service offerings and interfaces) and principles for the distribution of costs and revenues. A collaborative model can be likened to an ecosystem that gives the general public the possibility of holding and making payments with the e-krona.

The Riksbank can choose different levels of governance for participants in a collaborative model for the e-krona, ranging from a low level where the participants have great freedom of action to design services and interfaces with the public to a high level where the participants must comply with an interface and range of services defined by the Riksbank and standardised for all participants. The choice of the level of governance entails a balance between the opportunities and challenges inherent in the various alternatives. A low level of governance could promote competition and innovation but, at the same time, could result in the e-krona being implemented in different ways, making it difficult for the public to recognise. A high level of governance ensures that there is a uniform supply and uniformly designed services for the e-krona but can, at the same time, form an obstacle to competition and innovation as the opportunities for the actors participating in collaboration on the e-krona to design unique services are reduced.

The need for the state to ensure that a range of e-krona services are available to fulfil the basic needs of the public to make payments increases with weaker governance.

The Riksbank needs to conduct an in-depth dialogue with payment market participants covered by a possible future collaborative model for the e-krona in order to find a good balance between the overall objectives of the e-krona and the needs of the general public and the market.

DLT and blockchain-based technologies are often claimed to have advantages over more traditional account-based systems when it comes to the possibility of designing money and payment services in an innovative way. The focus of the technical work

was to test and investigate how programmability can be used in the technical platform on which the pilot is constructed and whether the platform and technology generally have advantages in this area. With regard to programmability, it is the possibility of conditional *payments* that is interesting in terms of the e-krona. It is therefore not the possibility of conditional *money,* as money that is programmed for special purposes loses a fundamental property of money: to be useable for payments in all contexts. The Riksbank's intention with a possible e-krona is not to try to control or limit what it could be used for. This would contradict the basic function of money and, in addition, could be interpreted as an infringement of personal privacy. The purpose of investigating programmability in the pilot is to learn more about how technical solutions can benefit customers by making payment services efficient and flexible.

During this phase, a practical use case was implemented in which a payment was made if, and only if, a specific condition was met. An investigation was also carried out comparing the technology with traditional account-based systems, where the main questions for the investigation were whether the technology can allow:

- The Riksbank to create technical frameworks in which the Riksbank sets certain rules for the e-krona and authorised participants can then create services within this technical framework.
- Simpler design, development and dissemination of more advanced payment services, such as conditional payments, which do not require the Riksbank to be directly involved in their design and distance the Riksbank from information about their use

This work has demonstrated how the technical solution can enable the development of payment services with more advanced logic and integration with external data sources. The technical investigation has also shown that the transparency of DLT and smart contracts can make it easier to ensure that, for example, a conditional payment lives up to agreed regulations. However, the technology itself does not eliminate the need for traditional regulation, oversight and trust between different actors and users. As mentioned in previous reports, the increased sharing of data in solutions like the one in the pilot raises a number of questions regarding banking secrecy and the protection of personal data, for example. More advanced payments that are conditional and dependent on factors such as external information may also mean that even more data on end users' purchases will be shared within the network. It is important that matters like this are investigated and managed carefully, not least to protect personal privacy.

The technical investigation shows that DLT may have certain advantages when developing and disseminating more advanced services within the platform and its participants. One important question for the continued technical work is therefore whether and, if so, how an infrastructure and collaborative model could be designed to enable basic e-krona functionality with high performance and security, while allowing the Riksbank to maintain its current role on the payment market to the greatest possible extent and also letting private actors utilise any advantages inherent in the new technology.

In phase 3, the Riksbank's e-krona pilot has also participated in a cooperation project with the Bank of Israel, Norges Bank and the Bank for International Settlement (BIS). The project, called Icebreaker, has demonstrated how cross-border payments could work using different central bank digital currencies. The model is based on the integration of each country's CBDC system with a separate hub. The hub enables the different CBDC systems to communicate with each other and matches end users with the participant offering the most affordable exchange between the various currencies (FX service). This matching also applies to end users who are already customers of a participant that also offers an exchange but at a higher price. These so-called FX providers are private actors, such as banks or other payment service providers, who are participants in at least two CBDC systems and who can thus receive a payment from the payer in the sending CBDC system and, in parallel, make a payment in the receiving CBDC system to the recipient, a so-called PvP (*payment versus payment)* with two currencies. The project uses HTLC (*Hash Time Lock Contract*) technology, which is a form of smart contract that can lock payments and thus ensure that the payment to the FX provider in the sending CBDC network only goes through if the payment from the FX provider to the final recipient has been executed in the receiving CBDC network. Icebreaker has demonstrated how the model of a central hub that enables communication between the individual CBDC networks and matches end users with the best offers from FX providers can enable payments between currencies in a way that can reduce risk and promote competition and speed. Icebreaker has also shown how the tested model can integrate CBDC networks built on different platforms in a way that involves few requirements and little governance over the design of each CBDC network.

2 The e-krona pilot

Since 2020, the Riksbank has been running a technical pilot project to learn more about how central bank digital money available to the public, an e-krona, could work. The e-krona pilot's test network is built on a DLT and token-based platform called Corda. By testing a technical solution, the Riksbank can learn more about the specific solution's potential to meet the e-krona's policy objectives and use it in comparisons with other types of solution. However, it has not been decided whether the Riksbank will issue an e-krona, nor how it would function or what technology it would be based on.

Cash is currently the only central bank money available to the public. However, recent technological developments have meant that physical cash is used less and less, while digital payment services are becoming increasingly popular. When cash takes a back seat in favour of digital services from private actors, the Riksbank's direct role on the payment market is reduced. The Riksbank may thus find it more difficult to fulfil its task of promoting a safe and efficient payment system accessible to all groups in society. The e-krona work conducted by the Riksbank and focused on by this and previous reports is therefore what is usually referred to as a *retail CBDC*, which is to say a central bank digital currency available to the general public. During the previous phases of the e-krona pilot, we have built up an e-krona network in a test environment in which e-kronas are distributed to end users via Riksbank-authorised participants in the network. The pilot has then gone on to test how an e-krona network could be integrated with the participants' internal systems, how an offline solution could work, how the e-krona could be integrated with existing POS terminals and what performance challenges the tested solution is facing.[1]

In the third phase, the work of the pilot has been limited to three areas with a focus on testing and investigating how:

- a cooperation model between the Riksbank and market participants could look when the Riksbank, as in the pilot, cooperates with the market to distribute e-krona to the public.
- this type of solution could contribute to innovation in the payment market, such as smarter and more efficient ways to pay.
- an e-krona network like the pilot could enable faster, safer and cheaper transactions between countries and CBDC networks. This has been investigated in a project called Icebreaker together with Norges Bank, the Bank of Israel and the Bank for International Settlements (BIS).

[1] The reports from phases 1 (https://www.riksbank.se/globalassets/media/rapporter/e-krona/2021/e-kronapiloten-etapp-1.pdf) and 2 (https://www.riksbank.se/globalassets/media/rapporter/e-krona/2022/e-kronapiloten-etapp-2.pdf) describe the Corda platform, how it is used in the e-krona pilot's e-krona network and other tests conducted as part of the pilot.

2.1 Future work on the e-krona

The work in the e-krona pilot is focused on testing and examining the conditions and challenges inherent in the implemented technical solution. The analyses and tests conducted in the work of the pilot are also linked to the conceptual design - the assumptions and distribution model on which the pilot is based. It has not yet been decided whether an e-krona will be issued and, if so, how it will be regulated and designed and which technical infrastructure and solution it will be based on. In addition to the technical work of the pilot, the Riksbank is therefore also conducting other, more theoretical investigations linked to the e-krona that, together with the technical lessons learned, will form the basis for the design of an e-krona should the decision to issue one be taken. Work going forward will be less focused on continued technical testing of the specific pilot solution and more focused on investigating the design of an e-krona ahead of the decision on possible issuance, alongside monitoring the international development of central bank digital currency.

3 An e-krona requires cooperation between the Riksbank and other actors in the payment market

A future e-krona that, like the pilot, is distributed to the public by the Riksbank and payment service providers in cooperation would be a new phenomenon on the payment market. There is therefore a need to identify which actors will cooperate and what components will be needed for this cooperation, such as participation conditions, regulations and an organisation for the operation, management and development of a future e-krona. Identifying actors and components makes it possible to start the work of designing a future ecosystem for an e-krona.

3.1 The e-krona - an ecosystem giving the general public the possibility of holding and making payments with the e-krona

A collaborative model is broader than a payment scheme and a payment system

The starting point for the e-krona pilot has been for the Riksbank to cooperate with actors in the payment market to ensure that the general public has access to the e-krona.
In the third phase of the e-krona pilot, the Riksbank has investigated how different possible models for collaboration could be designed. These models include the Riksbank and the actors who need to cooperate in connection with the issuance, distribution and use of the e-krona. One prerequisite for cooperation concerns the establishment of a basic structure in the form of conditions for participants, organisation, regulatory framework, principles for managing the brand, the services offered, interfaces with users and participants and the distribution of costs and revenues. A model for collaboration can be likened to an ecosystem that gives the general public the possibility of holding and making payments with the e-krona.

Internationally, the term *payment scheme* is used to describe a regulatory framework (rulebook) for payment transactions carried out via a specific payment instrument, such as direct debit.[2] Actors interacting in a payment scheme are usually the payer, the payee, the payment service provider and the regulatory framework (scheme)

[2] See European payment council, https://www.europeanpaymentscouncil.eu/what-we-do/sepa-payment-scheme-management/what-payment-scheme och artikel 2, and point 7 of Regulation (EU) No. 260/2012 of 14 March 2012 establishing technical and business requirements for credit transfers and direct debits in euro.

owner. A payment scheme is separated from the rules governing the relationship between payment service providers that are participants in the payment system in which the payment transactions are executed. Actors in a payment system that interact with each other are participants. These include payment service providers, the actor who is responsible for calculating the net amount of the payment transactions that the participants execute with each other (the clearing organisation) and the actor that provides services to carry out the change of ownership of the money exchanged when payments are executed, usually a central bank.[3]

A collaborative model is broader in scope than a payment scheme and a payment system, as the collaborative model encompasses all actors and components needed to establish an ecosystem for an e-krona from scratch. By identifying the model's components and actors, clarifying their mutual rights and obligations and describing the forms of their cooperation, the Riksbank will be able to make concrete its dialogue with the general public and payment market participants on the design of a future e-krona.

FACT BOX – components of a collaborative model

Use cases
Descriptions of how an e-krona solution will interact with its environment and the scenarios that need to be supported, such as payments between individuals.

Agreements
Agreements regulating the rights and obligations of the actors interacting in a collaborative model for the e-krona.

Certification
Process for ensuring that the solution for an e-krona is of high quality, for example by following up that actors and services comply with rules and security requirements.

End user interface
The digital interfaces in which the e-krona is presented to the public.

Legal framework
The legislation regulating the phenomenon of central bank money in digital form available to the public.

Organisation
The organisational forms necessary to allow the governance, management, operation and development of the components of a collaborative model. This is usually done by establishing working groups, decision-making groups and user groups. Examples of issues that need to be addressed in an organisational structure for the e-krona are changes to the regulatory framework and participation conditions.

[3] For more detailed information on the clearing and settlement process, see "The Swedish retail payment market", Sveriges Riksbank, 2013, pp. 23.

Operational management
Ongoing operation of the components of a collaborative model that are dependent on IT systems, such as IT systems for storing the e-krona.

Participant
An actor entitled to participate in an e-krona solution, such as a payment service provider, and to provide services to the public, such as acquiring, holding and executing e-krona payments.

Participation conditions
The conditions with which the participating actors in an e-krona collaborative model are obliged to comply.

Regulatory framework
The rules that govern the rights and obligations of the actors in an e-krona collaborative model. The rules may also include technical specifications for the payment messages exchanged and the design of communication links between senders and recipients of payments. The framework can be stand-alone or incorporated in the participation conditions.

Settlement
When a payment is concluded, it is settled. For payments within a bank, this is when the transfer is made between accounts. For payments between banks, this is when the money has reached the receiving bank.

Security solution
The solution that protects the e-krona and e-krona payments from observation, intrusion and manipulation. The security solution chosen in a collaborative model must be fully supported by the actors in the collaborative model.

Standards
It is currently possible for the general public to exchange money in payment accounts for cash, for example via ATM withdrawals. It is also possible to exchange cash for money in payment accounts, for example via deposit machines. Payments between payment accounts and e-krona electronic wallets require interoperability between an e-krona solution and the existing payment infrastructure. The use of standards for payments between e-krona wallets and payment accounts promotes interoperability.[4]

Trademark and logotype
The distinctive mark that symbolises an e-krona and that can be used by those actors who have entered into an agreement with the Riksbank to use the trademark, for example in the role of participant.

[4] Established technical solutions for payments between bank accounts are largely based on international standards such as ISO 20022 and the International Bank Account Number (IBAN), which have established management organisations. In addition to promoting interoperability, an advantage of using established standards is that the central bank does not need to build its own organisation to manage the standard.

3.2 What distinguishes collaboration on an e-krona from existing collaboration on payments?

It is important to identify the characteristics that are unique to the e-krona in order to clarify the division of responsibilities between the actors in a collaborative model like the pilot. The e-krona will be issued by the Riksbank, will be on the liability side of the Riksbank's balance sheet and will not be a legal claim on the participants in a collaborative model distributing the e-krona to the general public in cooperation with the Riksbank. A consequence of this is that the general public's e-krona holdings will not be on the liability side of the participants' balance sheets and the participants will not be able to earn a return on the public's e-kronas by lending them out.

The project has investigated whether technical solutions that use cryptology and the exchange of private and public keys in connection with the issuance of the e-krona can affect the design of a collaborative model. These solutions mean that the e-krona is designed like a physical banknote, in that each e-krona is assigned a unique identifier that enables it to be distinguished from other e-kronas. In the same way that the Riksbank occasionally needs to replace issued banknotes and coins to make them more secure, for example by adding higher quality paper and watermarks, the Riksbank may need to increase the security of this form of e-krona by periodically increasing the strength of the encryption. Such a process can be compared to the physical changeover of banknotes and coins and, even though the process does not involve the same extensive logistics, many of the actors in a collaborative model would be involved. The choice of technical solution for the design of the e-krona can thus affect the design of the collaborative model.

3.3 Analysis of existing collaborative payment models

The project has studied five existing payment systems for instant payments and four solutions for CBDCs and analysed their respective collaborative models based on three overall areas: *governance and regulations*, *business model* and scope in the form of *support for different use cases*.[5] The project has also related these systems and solutions to the overall objectives for an e-krona communicated by the Riksbank in previous reports on the e-krona.[6]

- Ensuring continued public access to central bank money in a digitalised society.
- Promoting competition and innovation in the payments market.
- Strengthening the robustness of the payment system by providing an additional payment method for the public.

[5] Instant payments: Swish in Sweden, Pix in Brazil, New Payment Platform (NPP) in Australia, United Payment Initiative (UPI) in India, RIX-INST in Sweden; CBDC initiatives: Sand dollar in The Bahamas, eNaira in Nigeria, eCNY in China and DCash within the Eastern Caribbean Currency Union (ECCU).

[6] See The Riksbank's e-krona project, Report 1, pp. 6-18, Sveriges Riksbank, 2017

How does the Riksbank's governance of regulations, business models and support for different use cases affect a collaborative model?

The Riksbank may choose to exercise various levels of governance over the actors and components of a collaborative e-krona model. The level of governance can affect the ability of participants to develop innovative payment services and compete with each other, as well as the public's ability to access basic payment services via the e-krona. Below follows a discussion of how governance of the regulatory framework, business model and support for different use cases could affect a collaborative model for the e-krona.

The regulatory framework and participation conditions specify which actors are entitled to act in the role of participant in a collaborative model and provide e-krona to the public. In cases where the participants are actors covered by existing regulation and supervision, such as payment service providers, the need for the Riksbank to produce new regulation is reduced, while the opposite applies if the participants are currently unregulated.

The principles for the distribution of costs and revenues (business model) are important in a collaboration model. In cases where the positive incentives are considered sufficiently strong, the conditions for establishing relations between the Riksbank and other actors on the basis of civil law agreements increase. In cases where the incentives are weak, the cooperation model may need to be supplemented with elements of regulation.[7]

Like physical cash, an e-krona could be regarded as an interest-free loan to the general public where the return generates revenue for the Riksbank, known as seigniorage, and contributes to the financing of an e-krona solution.[8] A CBDC where the costs are covered by seigniorage with no or low fees for participants would allow them to set a low price for priced e-krona services to the public.[9]

One of the starting points in the study of existing payment systems and CBDC solutions has been to identify which use cases are supported, such as payments between private individuals, to gain an understanding of their impact on the scope of an e-krona solution. One conclusion is that a solution that includes support for payments between private individuals and legal entities is significantly more extensive than a solution that only supports payments between private individuals. The main reason for

[7] The distribution model for cash is based on a combination of regulations issued by the Riksbank and agreements, while participation in the Riksbank's settlement system RIX is based on agreements. The criteria for participation in settlement systems are regulated by Directive 98/26/EC on settlement finality in payment and securities settlement systems

[8] For a more detailed discussion of the e-krona and seigniorage, see Economic Review 2020:2, Gustafsson and Lagerwall, Sveriges Riksbank.

[9] The ECB argues that a future digital euro would constitute a public good; see https://www.ecb.europa.eu/paym/digital_euro/investigation/governance/shared/files/ecb.degov230222_item4compensationmodel.en.pdf

this is that a new payment method needs to be integrated with existing payment terminals and point-of-sale systems in physical shops and e-commerce.[10] The scope of the solution and its complexity increase the more use cases that are supported and it is therefore important that the Riksbank prioritises the use cases that are initially deemed to provide the greatest benefit.[11]

The degree of governance and control over a collaborative model can affect the fulfilment of the objectives of the e-krona

The degree of governance of a collaborative model by the central bank has a crucial influence on its design.

Low degree of governance

A low degree of governance could mean that the Riksbank establishes guidelines that specify how the brand for an e-krona may be used. The actors who qualify to act in the role of participant are given great freedom to design services and interfaces for the e-krona on their own, based on a regulatory framework. One challenge with giving participants unlimited possibilities to design interfaces and services for an e-krona is that it may be difficult for the public to form a common understanding of what an e-krona is. There is also a risk that the services developed will not fulfil the needs of the population as a whole. The Riksbank may therefore need to decide on a minimum common denominator for the scope of a service range that all participants are obliged to provide.[12] In addition, participants would be free to design their own value-added services. Another alternative would be for the government to take responsibility for providing a basic range of services, in the same way as the government provides services for electronic mail to citizens.[13]

Even with a low degree of governance, the Riksbank needs to draw up participation conditions and regulations governing the participants' access to and participation in an e-krona infrastructure as well as the relationship between the Riksbank and the participants, including the participants' mutual rights and obligations. In general, the scope of agreements and regulations should still be relatively limited. An example of a low degree of governance in an existing collaborative model for payments is the *Faster Payments Service* in the United Kingdom.[14]

[10] GetSwish AB has established the role of "technical supplier" with responsibility for connecting retailers' payment terminals and point-of-sale systems. See https://www.swish.nu/faq/company/vad-menas-med-teknisk-leverantor

[11] Swish was introduced as a solution for payments in 2012 but has gradually developed support for payments between private individuals (P2P) and businesses (P2B, B2P). See https://www.swish.nu/om-swish. Banco Central do Brasil launched support for P2P, P2B and private-to-government (P2G), business-to-business (B2B) and business-to-government (B2G) in the PIX system from the beginning. https://www.bcb.gov.br/en/financialstability/pix_en

[12] It is common for actors in a collaborative model for payments to be obliged to provide certain basic services. See, for example, the NPC Credit Transfer Scheme Rulebook, Chapter 5.3, which states that participants are obliged to accept payments from other participants. https://www.nordicpaymentscouncil.org/npc-schemes/npc-credit-transfer-scheme-rulebook/

[13] Cf. the government mailbox for electronic mail. https://www.minmyndighetspost.se/

[14] https://www.wearepay.uk/what-we-do/payment-systems/faster-payment-system/

High degree of governance

A higher degree of governance would mean that the Riksbank, in addition to establishing guidelines for the use of the brand name for an e-krona, would also be responsible for design guidelines for digital interfaces, such as fonts, colours and the placement of e-krona services in the participants' existing interfaces, as well as for the design and scope of the services offered for the e-krona. In this case, the Riksbank would also need to build up an organisation for ownership, development, administration and follow-up of design guidelines and the range of services offered. An example of a high degree of governance of a collaborative model is Banco Central do Brasil's system for instant payments, *PIX*. [15]

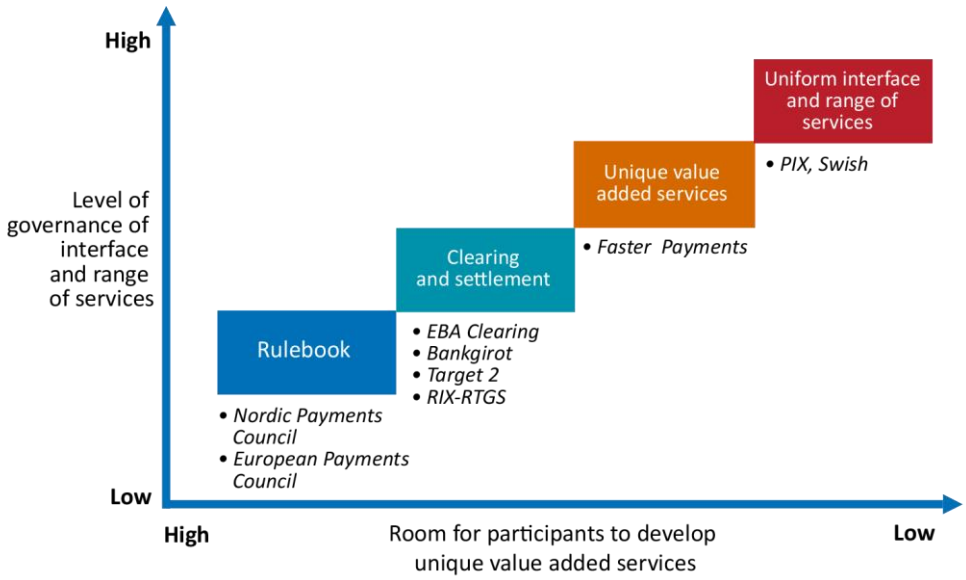
Very high level of governance

The highest level of governance would involve the Riksbank also establishing a common interface for all participants in the form of a mobile application (app). The interface and range of services for the e-krona would thus be standardised and common for all participants. Under this high level of governance, the central bank's responsibility as described in the alternatives above would be even more extensive and, in principle, all-embracing. Under this arrangement, the Riksbank would be responsible for the ownership and coordination of the operation, administration and development of the app's interface and its range of services. An example of a collaborative model for a payment solution in the private market where a very high level of governance is applied is the Swedish banks' cooperation on Swish, where the interface and range of services are uniform for all participants and their customers.[16]

[15] See https://www.bcb.gov.br/en/financialstability/pix_en

[16] See www.swish.nu

Figure 1. The level of governance of participants' interfaces and range of services in a collaborative model affects their ability to compete and innovate.



Regulatory framework (Rulebook), clearing and settlement usually form a common framework for the participants in a collaborative model. Outside of this framework, the opportunities to offer unique value-added services may vary.

A collaborative e-krona model needs to strike a reasonable balance between the overall objectives of the e-krona, the needs of the public and the needs of the market

Our review of the collaborative models for instant payments and CBDCs developed by other central banks shows that the majority of the solutions are based on relatively far-reaching central bank governance with uniform interfaces and a uniform service offering. This is particularly true for CBDC solutions where each of the four central banks whose solutions were analysed have developed a uniform mobile application for their CBDC.[17] However, such a high level of governance may reduce the scope for achieving the overall objectives of fostering innovation and competition, as it reduces the ability of participants to design their own unique e-krona services.

On the other hand, a low degree of governance makes it more difficult for the central bank to establish and maintain a uniform design that makes the e-krona more recognisable and includes a basic range of payment services that meet the public's need to make payments.[18] Even if the Riksbank were to require all participants to provide a minimum level of e-krona services, there is a risk that the services would be implemented and designed differently, which could lead to low recognition of the e-krona.

[17] The central banks of The Bahamas, China, Nigeria and the nations of the Eastern Caribbean Currency Union.

[18] Chapter 4 a of the Payment Services Act (2010:751) requires payment service providers to provide basic payment services to consumers.

An e-krona may lead to lower revenues for those participants that currently have large deposits from the general public if the general public chooses to exchange deposits for e-kronas, as they may have to replace those deposits with more expensive alternatives.[19] A low degree of governance by the Riksbank could lead to these participants not providing e-krona services or only a very limited range.

Ultimately, the level of governance is about balancing the challenges and opportunities presented by low and high levels of governance. A high recognition factor and a uniform design at the same level as cash need to be balanced against the promotion of innovation and competition. A low level of governance increases the need for the government to guarantee public access to a basic range of e-krona services to fulfil the need for payment services in the same way as the government currently provides services for electronic mail via a government electronic mailbox – Min myndighetspost.

A high level of governance limits the ability of participants to compete with unique services and thus inhibits innovation. However, other factors can offset these challenges. The government could take responsibility for the costs of operating, administrating and developing the e-krona technical platform and charge low or no fees for access to the platform. A government-owned and funded e-krona platform could also provide a continuity solution that relieves the commercial banking system in times of crisis and heightened state of alert.

This review was based on the e-krona pilot model with participants as distributors of the e-krona. The project's assessment is that there is a need to conduct an in-depth dialogue with payment market participants covered by a possible future collaborative model for the e-krona in order to find a good balance between the overall objectives of the e-krona and the needs of the general public and the market.

3.4 Reflections and lessons learnt on a collaborative model for e-krona

The starting point of the e-krona pilot has been for the Riksbank to collaborate with payment service providers to ensure that the general public has access to the e-krona.

- A collaborative model for an e-krona can be likened to an ecosystem that gives the general public the possibility of holding and making payments with the e-krona. Collaboration includes the design of participation conditions, management organisation, regulatory framework (including management of brand and interface, service offering) and principles for the distribution of costs and revenues.

[19] See Juks, Economic Review 2018:3, Special issue on the e-krona, "When a central bank digital currency meets private money: effects of an e-krona on banks", Sveriges Riksbank

- A collaborative model is broader in scope than a regulatory framework for payments and the payment system in which payment transactions are executed, as the model encompasses all actors and components needed to establish an ecosystem for an e-krona from scratch.
- By developing a collaborative model for the e-krona, the Riksbank will be able to concretise its dialogue with the general public and payment market participants on the design of a future e-krona.
- The properties of the e-krona differ from the properties associated with deposits in bank accounts. There is thus a need to clarify the division of responsibilities between the Riksbank and the participants that distribute an e-krona to the public within the framework of a collaborative model for the e-krona.
- The technical solution for the design of the e-krona may affect the design of the collaborative model.
- In the same way as physical cash, the e-krona could be regarded as an interest-free loan to the public where the return generates revenue for the Riksbank, known as seigniorage. This seigniorage could contribute to the funding of a solution for the e-krona and form an important component in the future distribution of costs and revenue between the Riksbank and participants in an e-krona solution.
- A solution for the e-krona that includes support for payments between natural persons and legal entities is significantly more extensive than a solution that only supports payments between private individuals because a new payment method would need to be integrated with existing payment terminals and point-of-sale systems in physical retail and e-commerce. The scope and complexity of a collaborative model increases with the number of use cases supported.
- The Riksbank can choose different levels of governance of participants in a collaborative model for the e-krona. Choosing the level of governance entails finding a balance between the opportunities and challenges inherent in the various levels.
  - A low level of governance could promote competition and innovation but, at the same time, lead to fragmentation and make it difficult for the public to recognise the e-krona.
  - A high level of governance would ensure that there is a uniform supply and uniformly designed services for the e-krona but could, at the same time, form an obstacle to competition and innovation as the opportunities for the participants to design unique services are reduced.
  - The need for governments to ensure that a range of e-krona services are available to fulfil the basic needs of the public to make payments increases with weaker governance.
- By adding value, the Riksbank could compensate for the limitations of a high level of governance. A government-owned and funded e-krona platform

could also provide a continuity solution that relieves the commercial banking system in times of crisis and heightened state of alert. The government could also take responsibility for the costs of operating, administrating and developing the technical platform for the e-krona.

4 The e-krona and programmability

One of the objectives of an e-krona is that it should be able to contribute to competition and innovation on the payment market. The idea is not that the Riksbank should be the actor that primarily designs services for end users. However, as the issuer of the e-krona and owner of its regulations, the Riksbank will be the one that can create the conditions for private actors to develop innovative services linked to the e-krona. An important issue for the Riksbank is to investigate which technical solutions for an e-krona best favour such innovations. DLT and token-based solutions, such as the Corda platform being tested in the e-krona pilot, are often highlighted as technologies that offer advantages in this area through their ability to programme money and payments for specific purposes. During the third phase of the pilot, the Riksbank investigated this further by testing the technical platform in practice and also theoretically investigating its advantages and disadvantages.

4.1 The relevance of new technologies to CBDCs

The ability to design conditional money and payments for specific purposes is often described as the future in terms of making money and payments smarter and more efficient. In recent years, so-called crypto-assets and stablecoins have emerged at an increasingly rapid pace, and the way these use new DLT technologies is claimed to be a good example of how the money and payment services of the future can be programmed and designed flexibly and efficiently.[20] In the CBDC debate, the possibility of innovation and programmability has therefore become a highly topical subject, as one of the intentions of CBDCs that is sometimes brought up is that they should be able to meet future needs for money with more flexible and smart functions. Using programming and code to control what should initiate a payment, for example, is not exclusive to a specific type of technology. Direct debit payments, which have existed for a long time, are an example of this. The CBDC debate, however, is more often about programmability where so-called smart contracts use code to digitalise agreements, for example, on conditional payments that can be executed using a blockchain solution if conditions are met. The technology is often highlighted as a solution that can enable, for instance, transactions between parties who lack trust in one another and without the need for a central actor to ensure that the transaction is carried out as agreed. The smart contract executes the payment, which reduces the risk of uncertainty that the payment will actually be made. The terms that determine the payment are also

[20] However, many of the aforementioned advantages of stablecoins, for example, are often related to their lower level of regulation, which has been proven to also pose risks. In addition, crypto-assets in particular have seen little use as a means of payment. For more information on crypto-assets and stablecoins, see: https://www.riksbank.se/en-gb/press-and-published/publications/staff-memos/an-overview-of-fintech-and-cryptoassets/summary/

immutable in the blockchain, making it clear what the payment was based on in the event of a dispute. Whether these alleged benefits of smart contracts and DLT are relevant for a CBDC issued by a central bank in a regulated network of central bank authorised participants is an important question being examined by many central banks in their CBDC work. And are there other potential benefits of the new technology in these areas that should be utilised in the design of a CBDC?

During the third phase of the pilot, the Riksbank tested and investigated whether, and if so how, the DLT technology (and in particular the Corda platform on which the e-krona pilot is based) could offer opportunities to develop innovative payment services. The aim was to learn more about this specific technology and the platform's potential to offer participants, such as banks and payment service providers, opportunities to develop new services for end users. However, the project also wanted to understand how the Riksbank, as the issuer of the e-krona, can set technical rules for the e-krona and test how participants in the e-krona network could develop new innovative services around the e-krona within these rules, while minimising the Riksbank's need to be involved in the design, control and dissemination of the services and avoiding insight into the user data generated by the services. And does the new technology offer any advantages in these areas over more traditional technologies relevant to a CBDC?

4.2 Conditional payments, not conditional money

A fundamental property of money is that it should be able to function as a universal means of payment within its currency area. Given that an e-krona would be money issued by the Riksbank that can be exchanged with other forms of the Swedish krona, it is therefore relevant to ask in what ways this money can be programmed before it loses this basic function and becomes something else. If conditions are placed on money, for example that it can only be used for certain purchases or on certain occasions, it risks becoming something more like a gift card and thus no longer money. But if the condition is instead attached to the payment, it can be likened to handing over cash provided that a certain condition is met. So the condition is attached to the specific payment and not to the money. If the condition is fulfilled and the cash is handed over, it is fully valid and works for the recipient just like other forms of money. A similar approach applies to an e-krona where programmability relating to the possibility of conditional payments is of interest. Not conditional money. The Riksbank's position is that any programmability on an e-krona should enable the development of efficient and user-friendly payment services, not limit or control the e-krona's areas of use. It is also important that personal integrity is safeguarded in the use of more advanced payment services. A similar approach has also been adopted by other central banks, such as the Bank of England, which has chosen to require user approval for programmability to be enabled for its digital pound.[21]

4.3 Use case conditional payment

To examine how programmability can be applied to the DLT platform on which the pilot's technical solution is based, we designed a use case with a payment service that enabled conditional payments. The project has not evaluated whether the use case would create value in a payment market. The use case should therefore only be interpreted as a way to test how services like the use case could be designed on the platform, what possibilities there are to ensure that the services comply with regulations and what other implications similar services may have.

In this case, a buyer wants to buy a specific car from a car dealer at an agreed price. The buyer and the dealer want a technical solution that allows each of them to fulfil their part of the transaction if, and only if, the other party fulfils its part. In this case, the condition for the transaction to be completed is that the amount from the buyer is correct according to the contract and that the car dealer has registered the buyer as the new owner of the specific car within a certain time. This is known as DvP (delivery versus payment).

The technology used in this use case is based on putting a conditional lock on the specific e-krona tokens to be included in the transaction from the buyer to the car dealer. As an event taking place outside the e-krona network, it needs to be verified that this condition, in this case the transfer of a car to a new owner, has actually been fulfilled. This requires a technical function that can read data sources outside the e-krona and thus verify that an event has taken place and sign a locked transaction. This function is

[21] The digital pound, speech by Jon Cunliffe, 7 February 2023, Bank of England.

carried out by a special node called the Oracle node, which is assumed to be operated by a trusted party in the e-krona network, such as a responsible authority or bank.

In the project, the conditional payment has been compared with escrow, where an intermediary, in this case a technological one, holds the money until the condition for the purchase has been fulfilled.[22] In this case, the technology is based on smart contracts and code on the platform that locks the money until a given condition has been met. At this point, the money is unlocked for the car dealer. If the time to fulfil the condition has run out, the money is unlocked for the buyer again. The Icebreaker project also tested another technical solution, HTLC, to lock payments (see Chapter 5).

As mentioned, the DLT and token-based solution also means that the underlying contract governing the conditional payment with its technical locking and unlocking must be in the e-krona blockchain, which raises questions, for example about how this information is handled within the network. The box below explains the use case (somewhat simplified) with its actors and processes.

FACT BOX – The payment process in the implemented use case

The use case includes a number of actors that enable the conditional purchase.

- **Buyer:** The owner of the e-kronas to be included in the transaction and the initiator of the purchase.
- **Car Dealer:** The seller of the car who is responsible for transferring ownership of the car to the buyer in a vehicle register.
- **Participants:** Banks or other payment service providers in the e-krona network that operate their own nodes, hold end users' e-krona wallets and develop payment services using the e-krona. In this case, this means the car purchase service.
- **Oracle node:** A trusted node in the e-krona network responsible for certifying events that occur outside the e-krona network. In this case, this means certifying that the car has been registered with the buyer in the vehicle register. The only task of the Oracle node is to approve the conditional payment when the car is transferred to the new owner, which unlocks the money for the car dealer. Other details of the transaction are unknown to the Oracle node.
- **Vehicle Register:** Simulation of a register of car ownership. This external database therefore exists outside the e-krona network.

[22] Escrow is an English term and legal institution for a contractual arrangement in which a third party acts as an intermediary between a payer and payee, usually for account funds that are paid out when specific conditions have been met, i.e. a type of deposit. In Swedish law, this is often formally treated as a pledge of funds on account.

The payment process

The pilot assumes that an authorised **Participant** in the e-krona network has designed the smart contracts needed for this conditional payment. Exactly what a payment with a use case would look like in reality in terms of the actors' interfaces and the order in which they act may, of course, vary. In the pilot's implementation, the process, somewhat simplified, looked like this:

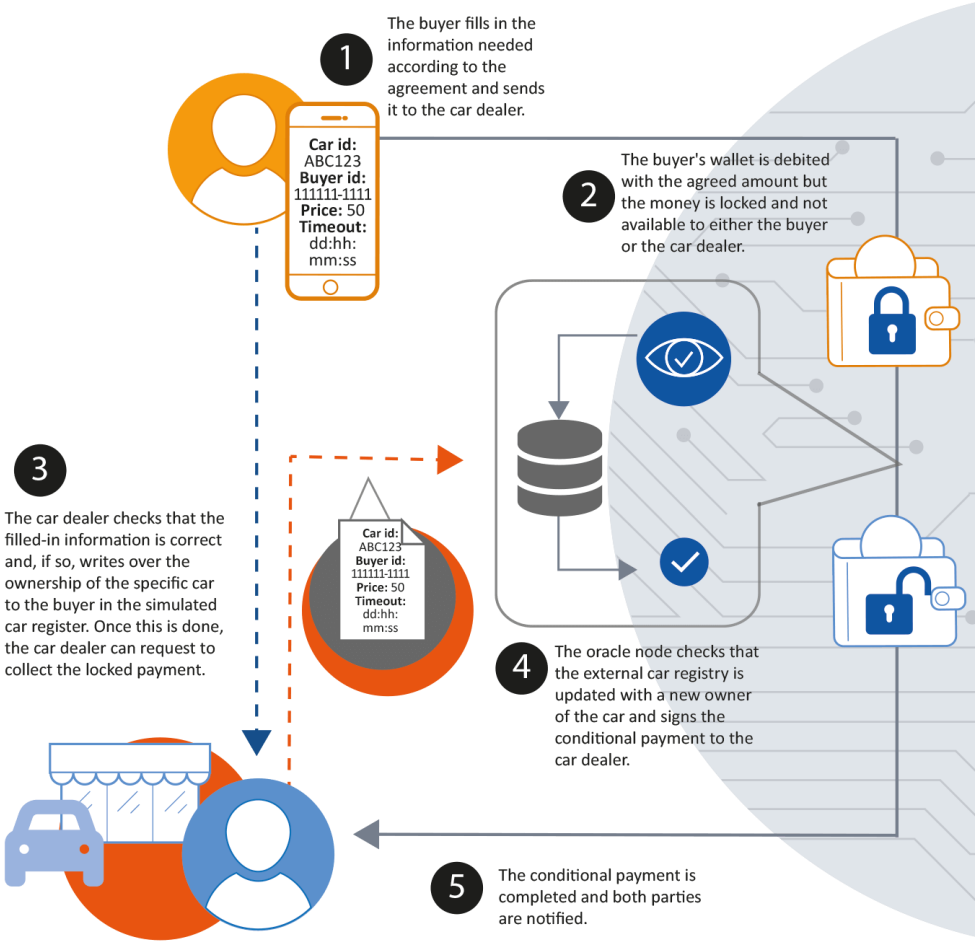
The **Buyer** starts the process by initiating a payment to the **Car Dealer**'s e-krona wallet with the information needed under the agreement the two have made on the car sale. The **Buyer** completes the terms and conditions necessary for the payment of terms and conditions to be made in his e-krona app. In this case, this concerns:

1. The registration number of the car to be purchased.
2. The personal identity number of the **Buyer** to whom the ownership of the car (registration number) is to be transferred.
3. The agreed price of the car.
4. Time frame for the condition (date and time). If the seller does not fulfil the conditions within the time frame, the money will be returned to the buyer.

When these details are completed and the payment is initiated and sent to the **Car Dealer**, the **Buyer**'s available funds have decreased and *technically* a transaction in the e-krona network has been completed but the funds are not yet available to any recipient, in this case the **Car Dealer**. It can be likened to the transaction being made with a "technical intermediary" where they are locked. In this situation, the money is not available to either the **Buyer** or the **Car Dealer**. For it to be unlocked and available to the **Car Dealer**, the **Car Dealer** must fulfil the conditions of the payment. In this case, this means that the **Car Dealer** needs to register the car with the new owner (the **Buyer**). Before registration, the **Car Dealer** checks that the information provided by the **Buyer** is correct according to the agreement. The **Car Dealer** then registers the car with the new owner in the **Vehicle Register**, which is an external database that has nothing to do with the e-krona. Once the **Vehicle Register** has been updated, the locked money can be unlocked and transferred in a new transaction from the "technical intermediary" to the **Car Dealer** as recipient. This transaction will be checked by the so-called **Oracle Node,** which can see that a correct transfer of ownership has been made in the **Vehicle Register** and can thus approve the transaction which is finalised as a normal transaction in the e-krona network. If the **Car Dealer** does not fulfil their part of the agreement and transfer the car to the **Buyer** within a certain time frame, the **Buyer** will be able to reclaim the money from the "technical intermediary".

The conditional payment thus requires a number of steps in which the smart contract is first created and then eventually executes an e-krona transfer. However, these steps are quick and the e-krona transfer is as fast as a regular transaction once the conditions have been met.

Figure 2. Conditional payment
Simplified illustration of the implemented use case



4.4 DLT does not eliminate the need for traditional regulations and supervision.

In addition to carrying out a practical use case with a conditional payment, a technical investigation was also conducted in which we compared how a DLT solution like the pilot's and a more traditional account-based solution could enable conditional payments. The purpose of this investigation was to understand whether the DLT-based solution has greater opportunities to create technical frameworks within the platform that can reduce the need for the Riksbank's direct involvement when new services are to be developed and thus reduce friction in the development of new and efficient payment services.

A CBDC system can be likened to a network with different participants and roles that together form an ecosystem for holding money and making payments. Like cash, an e-krona would be issued by the Riksbank and made available to the public via authorised participants in this e-krona network. As with cash, the credibility of an e-krona and its value as a means of payment would ultimately rest with the Riksbank. For the

physical cash that can be used independently of digital payment instruments, credibility is based on the fact that cash is difficult to counterfeit. For the digital e-krona that is intended to be used via various digital payment services designed by private actors, credibility is mainly based on the e-krona being based on a secure technology with a solid regulatory framework and credible actors.

The issue becomes somewhat more complex when the possibility of programmability is introduced. What types of payment services should it be possible to offer using the e-krona? Should all programmable payment services have certain common functions and rules? And what role should the Riksbank have as issuer of the e-krona? These questions are highly relevant in the work of investigating how the e-krona could contribute to competition and innovation on the payment market by allowing market participants to design new attractive services, while also guaranteeing the credibility of the e-krona in the services offered.

One question the project wanted to investigate is therefore whether, and if so how, the Riksbank could implement a technical framework and set certain rules for the e-krona with which participants in the e-krona network must technically comply. One such technical rule could be, for example, that a conditional payment must have a time limit for how long the money may be locked before it is returned to the buyer if the condition is not met. The approved participants should then be able to freely develop smart payment services within this framework. This is without the Riksbank having to be directly involved in the development of the services and actively checking that the services comply with the technical framework set up by the Riksbank. Nor should the Riksbank need to be involved in the dissemination of the services or have detailed knowledge of how they are used and by whom.

An important question in the technical design of an e-krona is therefore whether DLT-based solutions offer any advantages in this respect? Designing a technical framework that participants must follow technically without being able to make a deviation is not considered realistic. The technology would make it possible to create contract templates that incorporate the Riksbank's potential framework and allow private actors to design their own terms and conditions within this framework. These templates could make it clearer what must be in the contracts that the private participants develop for the e-krona, but there is nothing technical to prevent participants from breaking the rules of a template when designing their own contracts. However, the investigation suggests that the technology could provide the Riksbank with greater possibilities for monitoring the regulatory compliance of the services developed for the e-krona, as the smart contracts and the conditions applied to the payment are transparent to the participants in the network. A payment service built on a smart contract that has violated the rules that the Riksbank may have set for the e-krona would therefore be detected. Traceability and the possibility for templates for the contracts may thus make it easier to monitor compliance with any rules for smart contracts but the technology cannot remove the need for more traditional agreements, regulatory frameworks and supervision to monitor compliance with any rules. A relevant question is therefore how much value the technological possibilities for greater traceability have for ensuring compliance with the regulations?

The e-krona will be issued by the Riksbank and, as mentioned, the participants in an e-krona network, with the right to distribute e-krona and design payment services on the e-krona, will also be actors approved by the Riksbank. The participants will be part of a collaborative model with regulations, requirements and also incentives to design credible and secure services for customers. The transparency and traceability of DLT-based solutions, which are often highlighted as advantages for ensuring confidence in, for example, crypto-assets, are therefore not as relevant and applicable to a possible e-krona. Traceability, transparency and the possibility of finding out which parties and what was the basis of a transaction could instead become a challenge when the e-krona needs to fulfil the requirements of other regulations, such as data protection and banking secrecy.[23] From this perspective, the increased information on how the e-krona is used that are a consequence of conditional payments needs to be investigated further.

4.5 Can DLT facilitate innovation?

DLT and blockchain technology is often highlighted as more modern and flexible than the traditional account-based technology that is the most common way of recording balances and transactions. The use of the new technology and the elimination of the need for a central trusted agent is sometimes used to argue that private crypto-assets and stablecoins offer greater payment opportunities for the future. An e-krona issued by a central actor such as the Riksbank would, by definition, be completely different from privately issued stablecoins and crypto-assets. The question is therefore whether the claimed advantages are also relevant for regulated central bank money and, if so, how an e-krona could benefit from the new technology. And does the technology offer greater potential for a future payment market with even more digitalisation, automation and requirements for integration of other data? As the project has assumed that the Riksbank is not the actor that will primarily develop these services, this is very much a question of whether the technology can provide market participants with opportunities to more efficiently design, implement and disseminate innovative payment services on an e-krona platform.

A potential advantage of solutions built on DLT is that they often have smart contract functionality that makes it possible, for example, to reserve money for payments related to specific purposes and conditions. One example is the lock that locked the money into a specific condition in our use case with the car purchase. Managing different conditions and controlling how a payment is initiated and settled is also functionality that is often included in the basic design of the technology. As a result, DLT-based solutions are often highlighted as technologies that can provide increased opportunities if we move towards a 'tokenised' future where goods and assets of various kinds are given digital identities that can be bought and sold via smart payment services that streamline and automate transactions.

[23] See more about this in the E-krona pilot report phase 2, p.28. (https://www.riksbank.se/globalassets/media/rapporter/e-krona/2022/e-kronapiloten-etapp-2.pdf)

In a DLT-based solution, it may be more flexible to add and manage more advanced logic as functionality and standards, for example for how smart contracts are designed, controlled and managed, are available within the platform. By managing it within the same platform, it can mean fewer requirements for integrations between different actors and their different systems, which can reduce the obstacles to creating new services on a DLT-based solution. This, in turn, could contribute to the innovation of more efficient and cheaper services and increased competition in the payments market. It is possible to build similar functionality on traditional technologies, but this may require more effort unless the platform has inherent support for it and it requires synchronisation between different actors and systems.

4.6 Reflections and lessons learnt - the e-krona and programmability

Conditional payments are interesting for an e-krona. Not conditional money

A fundamental property of money is that its use is universal. Money that is conditional and can only be used for specific purposes loses this property. On the other hand, designing services where a payment is linked to a specific purpose and only executed if a certain condition has been fulfilled is consistent with the fundamental properties of money. The possibility of conditional payments using the e-krona is therefore interesting, unlike making the e-krona itself conditional.

The tested solution enables conditional payments

The tested solution has the technical capabilities to lock money tied to specific conditions, for example for conditional payments. Phase 3 has implemented two different methods in two different use cases to test this. The conditional car purchase and the cross-currency payment in Icebreaker (see more in Chapter 5).

The increased transparency of DLT and smart contracts does not eliminate the need for traditional regulation and supervision

The use of DLT and smart contracts offers greater transparency and traceability concerning which terms apply for a payment. This could lead to better possibilities for follow-up and investigation in the event of disputes. However, the technology does not eliminate the need for traditional regulations and supervision of the participants in an e-krona network. As e-krona services will be provided by authorised participants with strong incentives to create good and secure services for their customers, the value of a potential improvements in the ability to conduct of follow-ups as a result of greater transparency is assumed to be of minor importance.

DLT and smart contracts can facilitate the development and dissemination of new payment services

For its participants, DLT offers an advantage in that communication between nodes, the use of smart contracts and the settlement of payments and so on are conducted in the same way by all actors in the platform. This can reduce friction and increase flexibility, for example, in the development and dissemination of new services, which can contribute to increased innovation and competition.

DLT and conditional payments may mean greater sharing of information between network participants

Smart payments based on DLT and smart contracts may involve participants in the network sharing more information about end users' purchases. This may be problematic in relation to other regulations concerning the protection of personal data and information covered by banking secrecy. For the Riksbank, which wants to maintain its role on the payment market with the intention of knowing as little as possible about how end users use the e-krona, this is a potential disadvantage.

Basic e-krona functionality should be separated from more advanced payment services

Applying programmability in payments to the e-krona and the technology on which this should be based are also closely related to other issues such as the design of the distribution model and how balances and transactions should be recorded in an e-krona network. One disadvantage of DLT-based solutions is that they are often more complex and less efficient than more traditional account-based systems. This complexity certainly serves its purpose in certain areas of use. As mentioned, DLT-based solutions could offer increased opportunities by facilitating innovation between participants in the network. The main role of the Riksbank should be to provide access to the e-krona as a commodity, meaning a secure platform for holding e-krona and using e-krona in payments. It should also be possible to use these e-krona in more or less advanced payments subject to various conditions. The e-krona infrastructure should therefore be designed to allow it to utilise technologies that can offer efficiency gains. For example, it should be possible to construct services such as conditional payments in which an e-krona transfer is controlled by external events. However, this more advanced logic with possible links to external data sources that, for example, can lock the e-krona and only initiate a transaction subject to certain conditions does not necessarily need to be located where the e-krona is held and payments are settled.

This could be described as the e-krona having a core platform for the settlement of payments that will perform basic tasks such as holding and transferring money in a secure, high-performance and reliable manner. This platform could then be called, via well-defined APIs, by an upper layer in which market actors can use more advanced logic to set the conditions to for example reserve e-kronor and initiate a transaction. Market actors should have the best knowledge of the payment services demanded by their customers. They also know which technical solutions can best enable these. In such a model, the logic determining the execution of payments and integration with

external data sources would be designed by the private actors, using the technical solution they find most suitable for developing these services. By separating the core platform responsible for holding balances and settling transactions from the upper layer with room for more advanced logic, the e-krona can also be made more flexible and more adaptable to the new technical solutions and business models that are rapidly evolving in the field of payments. How such a model and infrastructure could be designed and what trade-offs would need to be made must be investigated further.

Division of responsibilities

From a legal point of view, risk and liability for conditional payments need to be apportioned. This can primarily be assumed to be a matter for the service provider to regulate as regards the end user/customer. But further legal analysis is also required concerning the extent to which the services that could be offered should be regulated, who should be allowed to offer them and how far the Riksbank's responsibility extends for the e-krona system.

5 Cross-currency payments – Project Icebreaker

Within the framework of the e-krona pilot and as part of phase 3, the Riksbank, together with the Bank of Israel, Norges Bank and the Bank for International Settlements (BIS), under the project name Icebreaker, has tested how the countries' domestic CBDC test networks could be integrated to enable and improve cross-currency payments. Icebreaker's model is based on individual CBDC networks communicating via a separate hub, with FX providers participating in multiple CBDC networks enabling end users to make instant cross-currency payments. The model is also based on the hub matching end users with the FX provider that offers the best exchange rate, which favours competition and transparency compared to how payments work today.

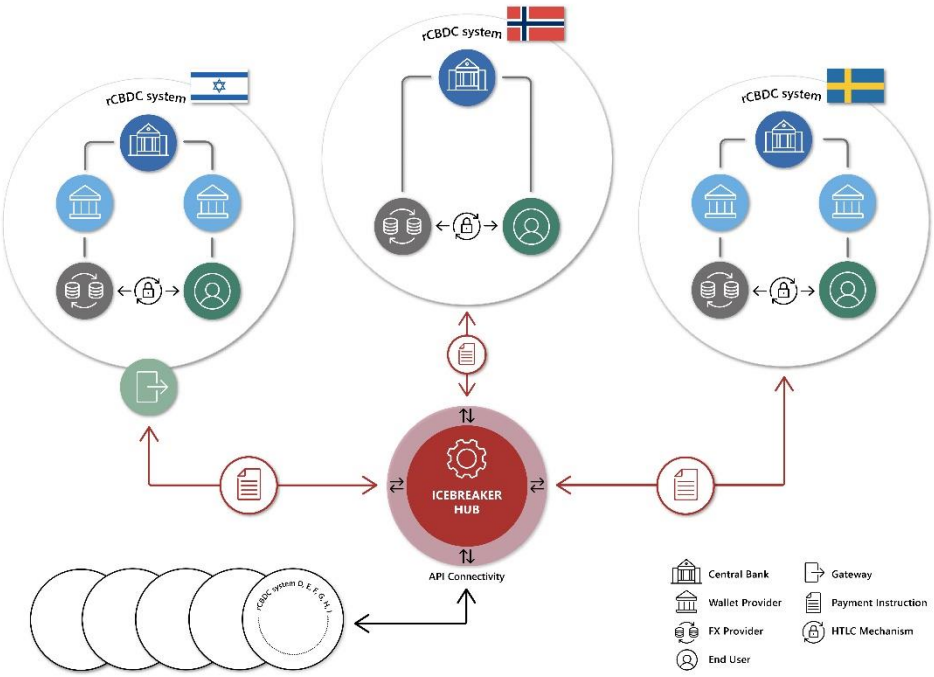
5.1 CBDCs could improve cross-currency payments

Although intra-currency and intra-country payments have improved and become much more efficient in recent years, payments between currencies and countries are still associated with high costs, long lead times and low transparency. The Icebreaker project has developed a model whereby different CBDC networks can communicate via a hub that enables payment messages to be sent between the individual CBDC networks. Cross-currency payments are executed using FX providers that are participants in at least two CBDC networks. A transaction is set up by the paying end-user addressing the recipient in the receiving CBDC network. This communication goes through the hub, which matches the payer with the FX provider offering the best exchange rate for the payment. If the payer accepts the exchange rate on offer, a payment procedure is created whereby a payment is set up in each CBDC network: one from the payer to the FX provider in the paying currency and one from the FX provider to the recipient in the receiving currency. The payment is designed so that when the recipient receives their payment, the FX provider get access to the information it needs to unlock their funds from the payer. This means that the payer only pays the FX provider once they, in turn, have paid the recipient in a PvP (*payment versus payment*). The technology used to make this possible is HTLC (*Hash Time Lock Contract*), which makes it possible to lock payments so that they can only be unlocked via the disclosure of a cryptographic password that acts as a key.

For a more detailed description of the project, see Icebreaker's final report: [https://www.bis.org/about/bisih/topics/cbdc/icebreaker.htm]

Figure 3. Icebreaker

Illustration of the Icebreaker model where the individual CBDC networks communicate via a separate hub



Source: https://www.bis.org/about/bisih/topics/cbdc/icebreaker.htm page 14

5.2 Reflections and lessons learnt - Icebreaker

The model on which Icebreaker is based offers a number of improvements compared to how cross-currency payments work today:

- The model decouples the payer from being dependent on a specific participant in the CBDC network for cross-currency payments, which means that a payer can always be offered the possibility of making such transactions regardless of the participant to which it is connected.
- By decoupling the payer from its participant, the end user is not bound by any exchange rate arrangements offered by its participant and will always be offered the best exchange rate via the hub.
- Decoupling thus increases competition between FX providers, while the model offers greater transparency to the payer as to which provider executes the payment.
- The model offers the possibility of making cross-currency payments entirely in central bank digital currency, while the use of HTLC allows the payment to be technically locked, reducing counterparty risks in payments.

By using a central hub to communicate between the different CBDC networks, a domestic CBDC network only needs to establish communication with the hub instead of

each individual CBDC network. For central banks investigating the possible introduction of a CBDC, the model may also be attractive as it places relatively few requirements on how the domestic CBDC must be designed in terms of both policy and technology choices. The main requirements are that the CBDC networks need to be available around the clock, support HTLC to lock and unlock the money, have participants that can act as FX providers, comply with the messaging standards and implement the APIs used to communicate with the hub. To be able to initiate payments between different CBDC networks easily, it is also important that the participating countries establish common and user-friendly ways to address payments between countries, for example via a joint standard for QR codes or alias databases. However, specifying and developing such a solution was not a priority of the project.

The project was focused on designing a model that would offer clear value to payers and payees, be relatively easy for different CBDC networks to connect to, and be scalable to handle increased volumes of transactions. The project was also focused on testing the capabilities of the technical solutions on which each CBDC network is based. However, several difficult issues related to cross-currency payments concern, for example, measures against money laundering and the funding of terrorism, and how the international hub should be regulated, owned and administrated. These issues have been addressed in the project but would need to be investigated considerably more before a model like Icebreaker could go into production.

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