Project Helvetia

Settling tokenised assets in central bank money

SCHWEIZERISCHE NATIONALBANK
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Foreword: BIS Innovation Hub

The Bank for International Settlements (BIS) established the BIS Innovation Hub (BISIH) in 2019 to foster international collaboration on innovative financial technology within the central banking community. The BISIH's mandate is to identify and develop in-depth insights into critical trends in financial technology of relevance to central banks, to explore the development of public goods to enhance the functioning of the global financial system, and to serve as a focal point for a network of central bank experts on innovation. It complements the already well established cooperation within the BIS-hosted committees.

Project Helvetia – as described in this report – is a prime example of how the BISIH, together with partners, can develop deep insights into the latest financial technologies and explore the development of central bank public goods. Project Helvetia investigates how central bank money can be used for settlement in a world where securities and other financial assets migrate from today's centralised financial market infrastructures to new so-called decentralised or tokenised platforms for trading and post-trading activities. One proof of concept relies on wholesale central bank digital currency (w-CBDC) whereas another is based on a link to the existing central bank system for wholesale payments.

Through public/private collaboration and experimentation, Project Helvetia facilitates a better understanding of both technical issues and policy implications of innovations in this sphere. Clearly, if w-CBDCs are to fulfil their potential and promise as a new means of payment, their design and implications deserve close study and consideration. This is possible only via continued deliberations and experimentations among central banks and with other stakeholders, such as market supervisors and not least the private sector.

I wish to thank our partners the Swiss National Bank and SIX for excellent teamwork, and I hope this report offers useful insights for the central banking community and for the interested public. Given the speed of digital transformation, central banks (and others) need to learn fast to make informed policy decisions.

Benoît Cœuré
Head, BIS Innovation Hub

Foreword: Swiss National Bank

As new technologies transform the global financial system, central banks' mandates for monetary and financial stability are as relevant as ever. Private sector innovations aim to increase efficiency but may also challenge the stability of individual institutions and the overall system. One central bank task is to facilitate a safe, efficient and evolving payment system. Increasingly, that means experimenting with new technologies to gain first-hand knowledge and make better policy decisions.

Switzerland is a leading financial and technology centre. Therefore, it is no surprise that the Swiss National Bank (SNB) aims to be at the forefront of understanding and responding to innovations in the financial system. Collaborating with the BIS Innovation Hub Swiss Centre and SIX Group AG, the SNB launched Project Helvetia. This joint experiment investigates how the provision of central bank money for wholesale settlement might be adapted if distributed ledger technology (DLT) and tokenisation are adopted by financial markets.

Project Helvetia has been a success. It showed, in a realistic near-live setting, that it is possible to provide central bank money to settle securities transactions using new technologies. It also showed that a central bank wishing to do so has options. Not only is it feasible to link the existing systems, but also a new kind of central bank money – a wholesale central bank digital currency – could be issued.

Yet despite the success, several questions remain unanswered. Just because a central bank can do something does not mean it should. Project Helvetia is a first step towards this broader understanding of the wider implications for the financial system. More work needs to be done in establishing a clear view on a central bank's role in any future system. The process for continuing this work and broadening it to consider wider cross-border implications is already under way.

Finally, irrespective of which technologies the financial markets adopt next, the safety and reliability of the underlying financial infrastructure must be preserved. If DLT can deliver significant improvements in securities trading and settlement, then central banks must be prepared. Yet this collaboration has an inherent value outside preparations for a particular future scenario. Project Helvetia has brought different and complementary perspectives and expertise to the table. In this regard, it is a model for how to see the bigger picture and enable future work towards a more innovative, secure and efficient financial system.

Andréa M Maechler
Member of the Governing Board, SNB

Foreword: SIX

The very core of what SIX represents is defined by the security, stability, efficiency and reliability of the services we provide. It is these values and quality that our clients can rely on. And it is their complete trust and confidence in the infrastructure we provide that have made Switzerland one of the best performing financial centres in the world.

Our unwillingness to compromise on the things that matter is complemented with a drive to continuously and consistently improve in every way. It is what makes SIX one of the world's driving forces behind innovation in the financial marketplace and a powerful supporter of all fintech-related activities.

This explains why – for decades – we have been at the forefront of breakthrough thinking and technologies on a global scale. The creation of the world's first fully electronic stock exchange in 1995 is just one example of how "being digital" is integral to our DNA.

And it is this digital DNA that helped us recognise, well before many of our peers did, that distributed ledger technology has the potential to fundamentally transform the financial industry – which is why we established the SIX Digital Exchange (SDX).

Our aim with SDX – jointly with our partners from the financial industry – is to explore the benefits of these new solutions and implement an integrated issuance, trading and settlement and safekeeping platform for digital assets so that the industry can carry out its transactions even more safely and efficiently in the future.

A key element to empowering such a future is central bank digital currency (CBDC). CBDC is a critical lever for the safe and efficient settlement of payments and securities. The joint work between SIX, the BIS Innovation Hub and the Swiss National Bank in exploring technical possibilities to make central bank money available on the SDX platform is a strong and significant sign that we are all moving in the right direction.

The outstanding collaboration between all parties over the past year has resulted in successful proofs of concept and provided us with deeply valuable insights. It is now crucial that we continue our journey incorporating our learnings and understanding the benefits to ensure that the added value for the Swiss financial industry will far outweigh the effort of innovation.

Jos Dijsselhof

Chief Executive Officer, SIX

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Executive summary

Around the world, central bank money is used to settle the vast sums traded in financial markets. For these markets, digitalisation has massively enhanced the speed and efficiency of trading, clearing and settlement. Yet structurally, not much has altered since the days of paper trading slips and fax machines. That might be about to change. The private sector is now investing heavily in distributed ledger technology (DLT) and tokenisation. This could transform how financial markets are organised in the future.

In Switzerland, private experiments in this area are close to becoming reality. The new SIX Digital Exchange (SDX) plans to launch soon, offering issuance, trading, settlement, management and custody of tokenised assets, ie assets that exist on a DLT platform, settled with a privately issued digital coin. The uptake of this platform and others in development around the world is unknown. Still, central banks have a natural interest in investigating how they might offer settlement in central bank money, should such platforms be adopted at scale. Thinking ahead is part and parcel of central bank mandates to preserve the safety and efficiency of financial markets and their infrastructure.

Project Helvetia is a joint experiment by the BIS Innovation Hub (BISIH) Swiss Centre, SIX Group AG (SIX) and the Swiss National Bank (SNB), exploring the integration of tokenised assets and central bank money on the SDX platform. Two proofs of concept (PoCs) for settling tokenised assets were conducted: (i) issuing a novel wholesale central bank digital currency (w-CBDC) and (ii) building a link between the new securities settlement platform of SDX and the existing central bank payment system. Experiments confirmed both PoCs as realistically possible. Specifically, both PoCs used the testing environments of live or near-live systems, and transfers were shown to be legally robust.

Comparing the two PoCs reveals different benefits and challenges. A w-CBDC, existing on a permissioned DLT platform, accessible to financial intermediaries, opens up more of the functionalities possible with tokenisation (eg instant and simultaneous settlement). Yet issuing a w-CBDC that captures these possibilities would also bring new operational challenges and raise novel policy and governance questions for central banks. Linking a DLT platform to the central bank payment system, in contrast, has fewer challenges but also omits many of the potential benefits of a complete integration.

The testing environments of live or near-live systems added complexity yet realism to the project. That said, the designs of the PoCs were intentionally poles apart. Differently designed w-CBDCs that balance risks and benefits need to be explored further. The next steps for this future work are to gain a better understanding of the technical questions and policy implications of integrating a w-CBDC into the existing financial system. Progressing with this work is neither a signal nor a commitment by the SNB to issue w-CBDC.

Project Helvetia is an example of how open collaboration can further improve the common understanding of the impact of digital innovation on the future of the financial system. It helps central banks fulfil their mandates and contribute to the broader international discussions on CBDC. The BISIH Swiss Centre, SIX and the SNB are all committed to progressing in this spirit.

1. Introduction

Today, most financial assets are digital. Yet, in many ways, the processes for trading and settling these assets mimic those set down when trading was carried out in pits by open outcry and settlement was the transfer of a paper certificate.[1] Digitalisation of this process has enabled automation to a significant degree and made it much faster, yet the essential architecture persists.

Innovations in technology could allow for a different, possibly more efficient architecture. Today, centralisation of issuance (at central securities depositories (CSDs)), trading (at exchanges or other marketplaces), clearing (at central counterparties (CCPs)) and settlement (at CSDs and central banks) characterise markets and the underlying infrastructure. Distribution (eg through use of distributed ledger technology (DLT)) of any part of the process could change the architecture. Specifically, if assets were issued or represented on a DLT platform ("tokenised assets"[2]), then issuance, trading, clearing, settlement, asset servicing and custody may also need to change.

The private sector is experimenting with these new technologies. Today, no wholesale financial market uses DLT and tokenised assets. Yet some financial market infrastructures (FMIs) are actively working to change their systems, eg SIX Digital Exchange (SDX).[3] Central banks have a natural interest in strengthening and preserving the safety and efficiency of financial markets and their infrastructure. Therefore, understanding the potential changes brought about by DLT and tokenised assets is essential for a central bank as an operator of a real-time gross settlement (RTGS) system and as an overseer of the wider system.

One of the fundamental purposes of central banks is to provide a safe and liquid settlement asset. The widespread use of central bank money for large and critical settlements is pivotal to the functioning of the global financial system, offering safety, availability, efficiency, neutrality and finality (CPSS (2003)). International standards require FMIs to settle in central bank money wherever practical and available.[4] Central banks are experimenting with new technology to make sure that if the architecture of the financial system changes, central banks can continue to offer settlement in central bank money – for example, through a central bank digital currency (CBDC) or enhanced interoperability of existing arrangements.

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[1] In many markets, front office staff would record trades on paper slips, which would then be transferred to the back office. The back office would confirm the trade details with the counterparty (over the telephone) and then organise the settlement of securities and funds. Days later, when settlement was due, the back office would check that it had received and sent securities and money as part of its reconciliations.

[2] For a discussion of tokens in payment economics see CPMI-MC (2018) and of digital tokens see CPMI (2019).

[3] Others include the Australian Securities Exchange (ASX (2017)) and The Depository Trust & Clearing Corporation (DTCC (2020)).

[4] Principle 9 of the Principles for Financial Market Infrastructures (CPMI-IOSCO (2012)).

The planned go-live of SDX has led the BIS Innovation Hub (BISIH) Swiss Centre, SIX Group AG (SIX) and the Swiss National Bank (SNB) to join forces in Project Helvetia to explore the settlement of tokenised assets in central bank money. The project was carried out in the test environments of the live Swiss RTGS Swiss Interbank Clearing (SIC) system, and the near-live SDX platform. Two options to settle tokenised assets in central bank money were investigated: in a first proof of concept (PoC), a wholesale CBDC (w-CBDC) was issued on the SDX platform for the settlement of tokenised assets; in a second PoC, the SDX platform was linked to SIC, to allow the settlement of tokenised assets against payments in SIC balances.[5]

The PoCs were purely experimental and served to assess functional and legal aspects. They should not be interpreted as an indication that the SNB is to issue w-CBDC onto the SDX platform or to allow settlement of SDX transactions in SIC. Project Helvetia explored a w-CBDC, restricted to banks and other financial institutions. A retail or general purpose CBDC would address different use cases and raise very different policy implications (Group of central banks (2020)).

This report summarises the work carried out in Project Helvetia, comparing the two PoCs conducted by the BISIH Swiss Centre, SIX and the SNB. Section 2 describes the trading, clearing and settlement landscape in Switzerland. Section 3 explains the objectives, scope and design of the PoCs in more detail. Section 4 presents the functional and legal findings and Section 5 sets out the central bank policy considerations. Section 6 concludes with an outlook on possible future work.

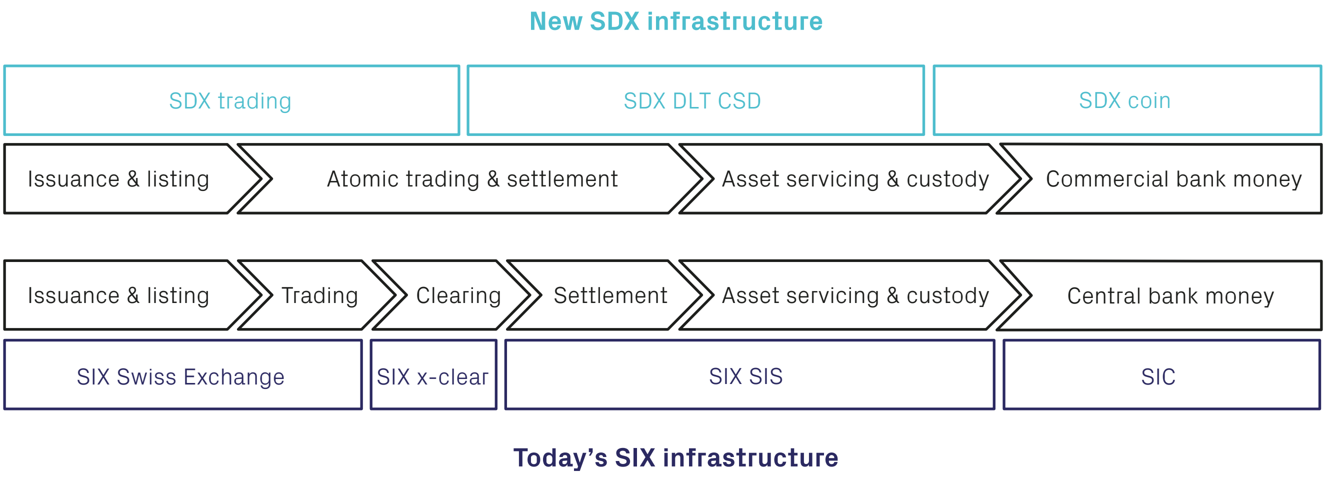
[5] In its go-live solution, SDX will issue a Swiss franc stablecoin ("SDX coin"), funded one-to-one by participants' SIC balances. In contrast to w-CBDC, the SDX coin is a liability of SDX.

2. Trading, clearing, settlement and custody in Switzerland —

Switzerland's financial market infrastructure for trading, clearing, settlement and custody is dematerialised and highly centralised, automated and fast. SIX provides essential elements of the financial market infrastructure in Switzerland and is owned by its member institutions.[6] It operates the stock exchange, the CSD and the CCP, offering issuance and listing, trading, clearing, settlement, domestic and cross-border custody as well as asset servicing (in addition to other data and payment services). The stock exchange and the CSD collectively underpin the trading and clearing of securities worth 3.4 trillion Swiss francs.[7] The final payments for the transfer of securities take place in central bank money on the Swiss RTGS system, SIC, which SIX operates at a subsidiary on behalf and under the oversight of the SNB (Graph 1).

SIX is building a new, complementary DLT platform, run by its fully owned subsidiary SDX. SDX plans to offer issuance, listing, trading, settlement, servicing and custody of tokenised assets with streamlining and automation of asset servicing and post-trade processing. Using smart contracts, business logic such as corporate actions or dividend payments can be implemented directly on the distributed ledger. Issuers and platform participants can also add logic to tokens, allowing additional streamlining and automation of asset servicing.

Graph 1: New SDX infrastructure and today's SIX infrastructure



[6] SIX is owned by around 120 Swiss and international financial institutions (SIX (2020)).

[7] As of 2019 (SIX (2020)).

SDX has applied for licences with the Swiss Financial Market Supervisory Authority (FINMA), both as a stock exchange and as a CSD. If granted these licences, SDX would provide its services as a regulated FMI only to licensed financial institutions. There are three key elements:

- The SDX trading entity (SDX Trading AG) provides stock exchange services, eg listing and trading of tokenised assets on the SDX platform. It operates on a similar infrastructure and uses similar processes to the traditional Swiss stock exchange operated by SIX. Trading occurs through a continuous, auction-based market model, with the matching technology provided by Nasdaq.

- The SDX CSD entity (SIX Digital Exchange AG) runs the DLT platform based on Corda from R3. The platform provides issuance, settlement, asset servicing and custody for tokenised assets. SDX supports two different trading options (Annex B): (i) on-exchange on-book trading with multilateral settlement; and (ii) off-book and off-exchange over-the-counter (OTC) trading with bilateral settlement. Trades settle according to delivery-versus-payment (DvP) model 1.[8] In contrast to the existing market infrastructure of SIX for equities, there is no CCP, as, after orders have been matched, trades settle instantaneously and simultaneously. With this "atomic" trading and settlement, settlement is instant, with settlement and replacement cost risk avoided (Bech et al (2020)).

- To enable the settlement of tokenised assets on the distributed ledger, SDX will issue a Swiss franc stablecoin.[9] The "SDX coin" will be funded one-to-one by participants' SIC balances but will be a liability of SDX.

The SDX DLT platform can be categorised as a private permissioned peer-to-peer network with hierarchical access to the ledger.[10] In this context, two aspects are particularly important: states and nodes. *States* are pieces of information at any given point in time, eg an asset definition, a participant's asset balance or a settlement or payment instruction. Any modification of information results in the creation of a new state, invalidating at least one previous input state. At any given point in time, the ledger is the sum of all states.

[8] DvP model 1 settles securities and funds on a gross and obligation-by-obligation basis, with final (irrevocable and unconditional) transfer of securities from the seller to the buyer (delivery) if and only if final transfer of funds from the buyer to the seller (payment) occurs (CPMI-IOSCO (2012)).

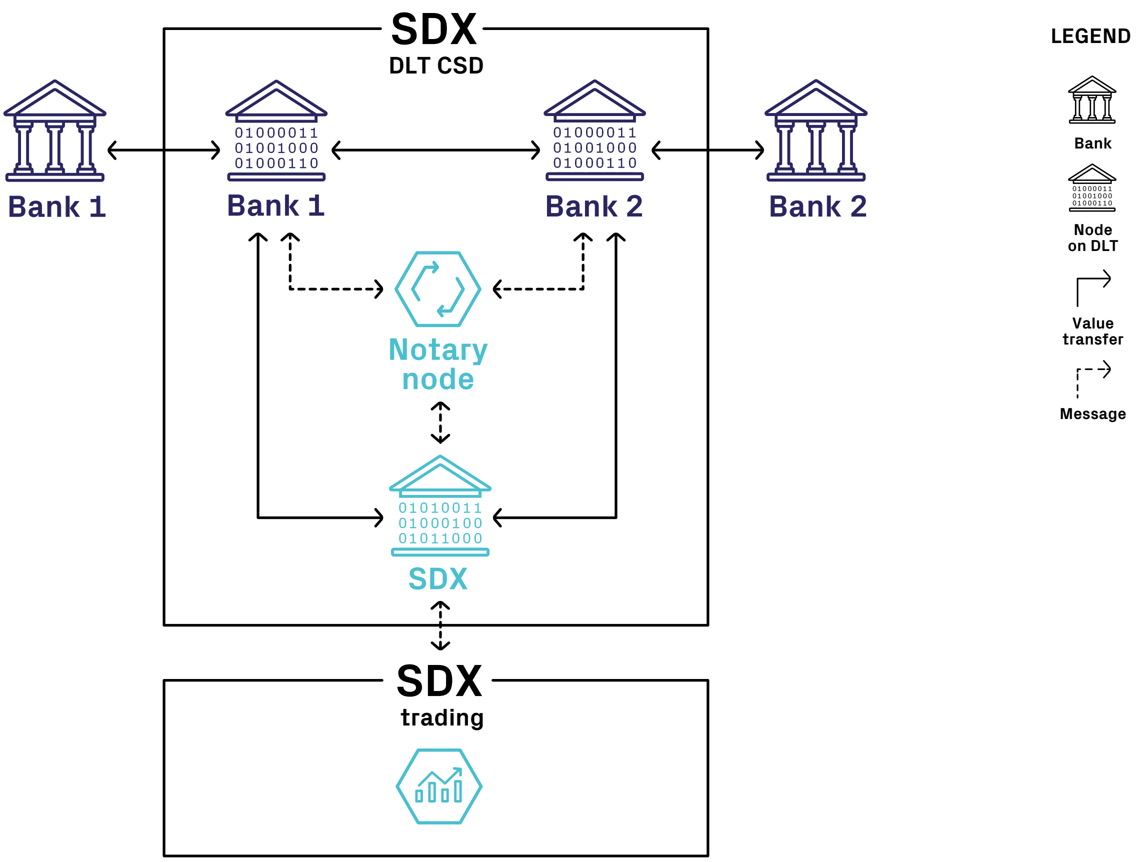
[9] A stablecoin seeks to stabilise the price of the coin by linking its value to that of a pool of assets (G7 Working Group on Stablecoins (2019)). In the case of the SDX coin, its value is linked to that of the Swiss franc.

[10] Annex C highlights selected aspects of the SDX technical infrastructure.

Nodes both store and update states that make up a ledger. The ledger is decentralised with peer-to-peer functionality. There are three node types on the SDX platform (Graph 2):

- **Participant node:** Each participant operates a participant node (eg Bank 1 node). Participant nodes can store states, initiate new transactions and execute business logic.
- **SDX node:** The SDX node is operated by SDX. It can store states, initiate new transactions, and execute special business logic available only to SDX. For example, it orchestrates and executes multilateral settlement instructions from SDX Trading and executes the business logic for issuing or redeeming the SDX coin.
- **Notary node:** The notary node is operated and controlled by SDX. It has two crucial functions: (i) preventing double-spending of any kind of tokenised assets in the network; and (ii) ensuring finality. To perform those functions, the notary node signs and time-stamps all state changes, while not seeing or validating the business content of a transaction. Within SDX, consensus is hence centralised in the notary node. The notary node characteristics are crucial for the safety and integrity of SDX as an FMI.

Graph 2: Topology of SDX



3. The project

Project Helvetia is a collaborative experiment between the BISIH Swiss Centre, SIX and the SNB, to explore the settlement of tokenised assets in central bank money. The experiments were executed in the test environments of the live Swiss RTGS system (SIC) and the near-live systems of SDX. The SNB defined the role and properties of central bank money in the experiments. The SNB and the BISIH Swiss Centre analysed the policy considerations, leveraging the DLT platform by SDX and building on the past experiments of other central banks (Annex A).

3.1 Objectives and scope

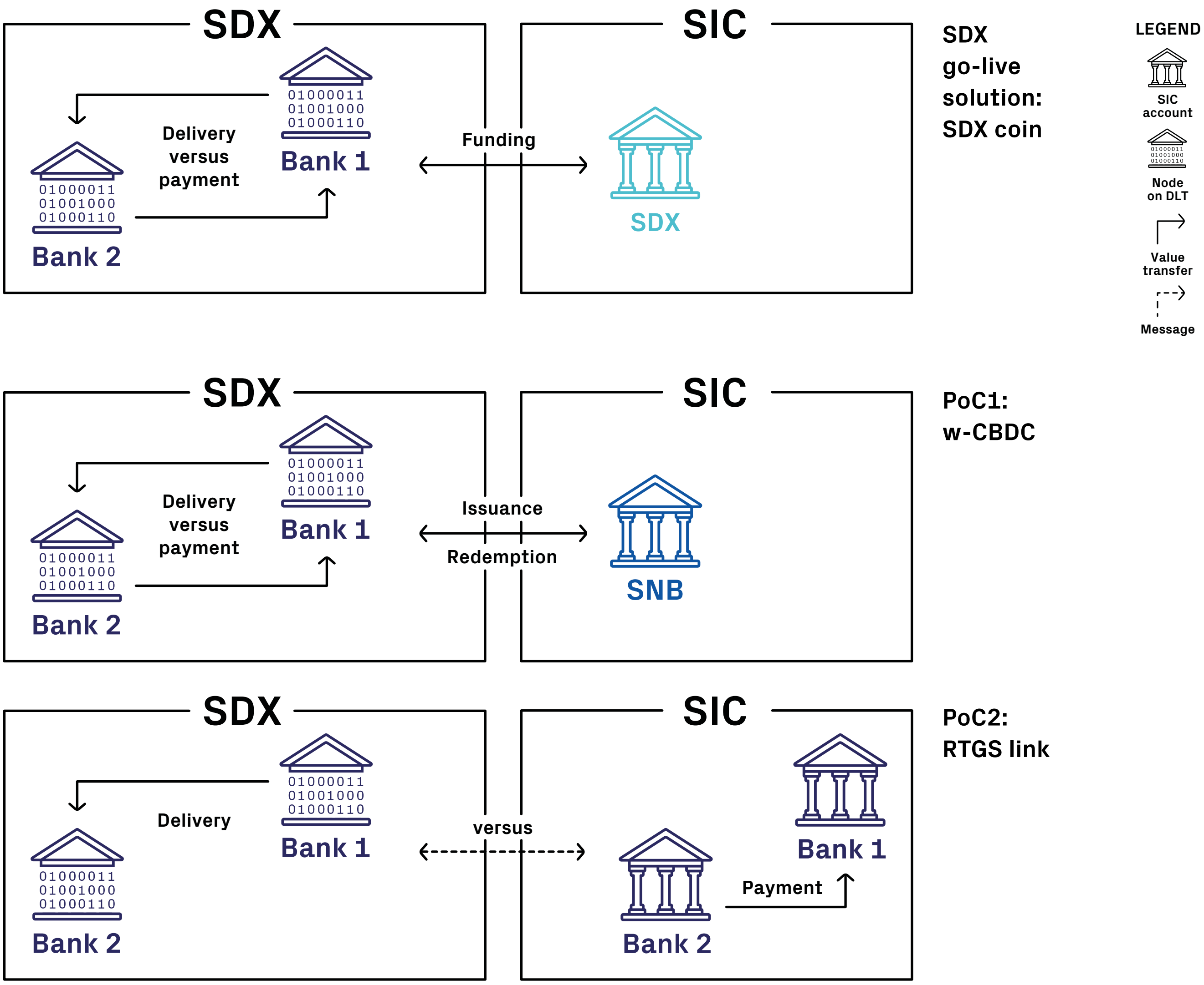
Project Helvetia explores two ways of settling tokenised assets in central bank money (see Box A for an overview of settlement arrangements for traditional securities and tokenised assets). In both ways, settlement is DvP. The two ways are referred to as proofs of concept (PoCs) 1 and 2, respectively. In PoC1, tokenised central bank money (w-CBDC) is issued onto the DLT platform. In PoC2, central bank money – just like today – remains in the RTGS system.

- **PoC1 – w-CBDC:** Issuance (and redemption) of w-CBDC on the DLT platform for payments and DvP settlements.

- **PoC2 – RTGS link:** In DvP transactions, tokenised assets are delivered on the DLT platform, and payments settle in the RTGS system.

The PoCs differ from the SDX coin envisaged for the launch of the service. The SDX coin is a claim on SDX, not on the SNB, even though it is funded through SIC balances (Section 2). Graph 3 contrasts the SDX coin with the two PoCs. While the envisioned SDX go-live solution and PoC1 are technically similar, PoC1 is central bank money and the SDX coin is not. Central bank money in the SIC system only funds an SDX coin, whereas in PoC1 an issuance of w-CBDC would reduce SIC balances and increase w-CBDC balances one-to-one (vice versa for redemption). PoC2 is different again, as the settlement leg remains in SIC.

Graph 3: Overview of SDX go-live solution, and PoC1 and PoC2



The PoCs focus on the functional and legal aspects of different settlement arrangements for tokenised assets. They also identify related monetary, financial stability and payments policy questions. Some aspects were excluded from the PoCs, eg regulatory, constitutional and tax questions and governance considerations as well as security, business continuity and other technical aspects. These aspects might be considered in follow-up work (Section 6).

Each of the two PoCs involved four steps: (i) deciding on the tasks that the SDX and SIC system need to perform to achieve DvP settlement against central bank money (use cases); (ii) establishing requirements that the SDX and SIC system had to fulfil when carrying out the tasks (business requirements); (iii) designing the processes within the SDX and SIC system that will capture the tasks and requirements (solution designs); and (iv) testing the implemented solution designs using the respective test environments. These four steps are outlined below for the two PoCs.

Box A: Settlement with tokenised securities and wholesale CBDC

Tokenising money and financial assets will change how they are settled (Bech et al (2020)). Table A1 presents a simple 2x2 taxonomy. The top left-hand quadrant represents existing arrangements, where assets exist in traditional CSDs and paying for them requires a transfer of balances held at the central bank. The lower left-hand quadrant shows tokenised assets settled in central bank balances (via a link to the existing RTGS system, as developed in PoC2). In the top-right quadrant, traditionally held assets are settled with wholesale CBDC (w-CBDC). Although theoretically possible, this aspect was not part of Project Helvetia. Finally, the lower-right quadrant shows tokenised assets settled against w-CBDC.

Table A1: Taxonomy of "tokenised" settlement

		Cash leg (payment in central bank money)	
		Reserve balances	**Wholesale CBDC**
Asset leg (delivery)	**Traditional assets**	Today's arrangement: securities in traditional CSD, reserve balances in RTGS	Not part of Project Helvetia
	Tokenised assets	**PoC2: RTGS link**	**PoC1: w-CBDC**

3.2 Use cases

A use case is a list of actions or event steps that a system needs to perform to meet its objective. The objectives of PoC1 and PoC2 are to demonstrate the feasibility of DvP settlement of tokenised assets against w-CBDC in SDX and SIC balances, respectively. For each PoC, the use cases are the individual or collective tasks that the SDX and SIC system need to perform to achieve "tokenised" DvP settlement. For PoC1, the settlement asset (ie w-CBDC) does not currently exist and hence the use cases include both the issuance and redemption thereof. Moreover, once w-CBDC is issued, w-CBDC payments (free of delivery) are also possible and were included as an additional use case. PoC2 involved a single use case (DvP settlement).

Use cases in PoC1 – w-CBDC

I. **Issuance of w-CBDC:** one-to-one conversion of RTGS balances into w-CBDC.

II. **Redemption of w-CBDC:** one-to-one conversion of w-CBDC into RTGS balances.

III. **DvP settlement in w-CBDC:** delivery of tokenised assets against w-CBDC (both on DLT platform).

IV. **w-CBDC payment:** a transfer of w-CBDC on DLT platform (free of delivery).[11]

Use cases in PoC2 – RTGS link

I. **DvP settlement in RTGS balances:** delivery of tokenised assets on DLT platform against RTGS balances.

3.3 Business requirements

Business requirements describe the characteristics of a proposed system from the viewpoint of a system's manager or end user. In Project Helvetia, the SNB performed the role of system manager.

Business requirements for PoC1 – w-CBDC

1. The central bank is the sole issuer of w-CBDC.
2. The central bank's balance sheet size remains unaffected by issuance and redemption of w-CBDC.
3. The central bank's reserve balances and w-CBDC are convertible one-to-one.[12]
4. The central bank controls access to w-CBDC.

[11] This use case was not necessary to demonstrate DvP but was included to evaluate the use of w-CBDC on SDX for payment purposes.

[12] The business requirements of PoC1 require one-to-one convertibility of w-CBDC and reserve balances whereas use cases refer to convertibility between w-CBDC and RTGS balances. For this report, RTGS balances and reserve balances are synonyms. In reality there are operational differences. In the case of the SNB, reserve balances are held in sight deposit accounts, which can fund RTGS settlement accounts through which payments are made and received during the day. Legally, these two accounts form a single legal entity and balances are also convertible one-to-one.

5. The central bank's reserve balances and w-CBDC have the same value date.
6. The central bank retains control and monitoring of w-CBDC settlement.
7. The central bank's reserve balance remuneration also applies to w-CBDC.
8. Issuance of and settlement with w-CBDC must be robust and final under the applicable legal framework.

PoC1's business requirements 1 to 3 are relevant only for the issuance and redemption use cases, whereas 4 to 8 are relevant for all use cases. Issuance and redemption of w-CBDC is controlled by the central bank (business requirement 1). It must be frictionless, fast and simple to allow for one-to-one convertibility between reserve balances and w-CBDC (business requirement 3). One-to-one convertibility is reinforced by equivalence between reserve balances and w-CBDC for: (i) access policies; (ii) value date; and (iii) remuneration (business requirements 4, 5 and 7, respectively). Control and monitoring of w-CBDC settlement (business requirement 6) allows the central bank to reconcile end-of-day balances and to remunerate w-CBDC. The implications from w-CBDC for the central bank balance sheet (business requirement 2) are discussed in Box B.

Business requirements for PoC2 – RTGS link

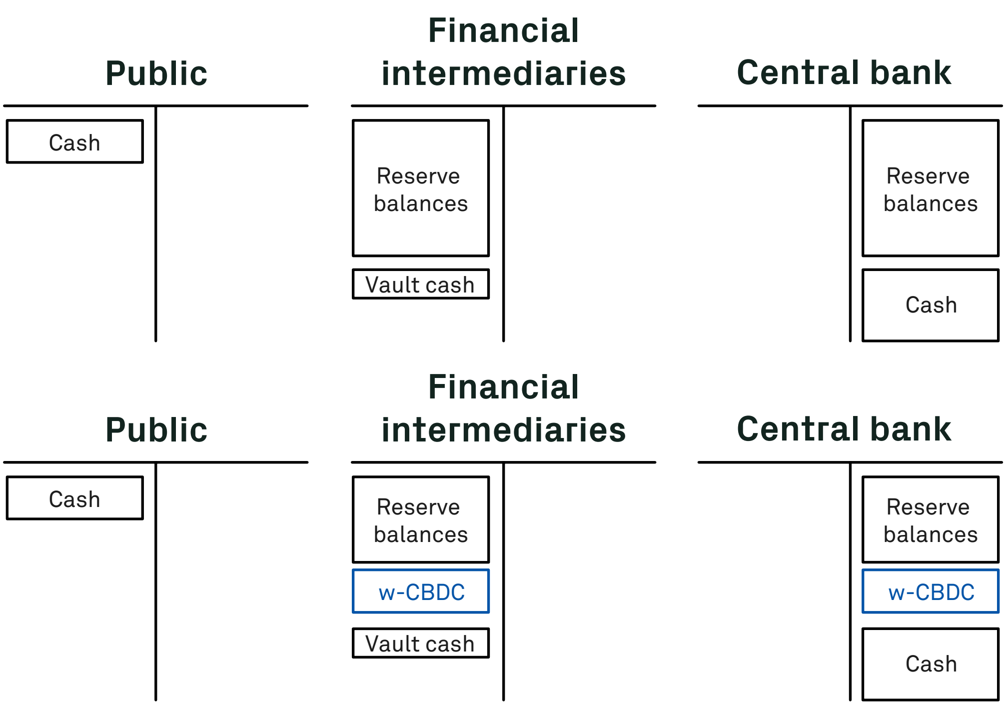
1. Settlement of tokenised assets in RTGS balances occurs according to DvP model 1.
2. The central bank controls who is eligible for DvP settlement of tokenised assets in RTGS balances.
3. Settlement of tokenised assets in RTGS balances is possible only during RTGS opening hours.
4. Settlement of tokenised assets in RTGS balances will not require any changes to the RTGS system.
5. The central bank retains control and monitoring of settlement of tokenised assets in RTGS balances.
6. Settlement of tokenised assets in RTGS balances must be robust and final under the applicable legal framework.

Box B: w-CBDC and the central bank balance sheet

The monetary base (in many countries referred to as "M0") is money directly created by a central bank. It comprises the stock of central bank money held by commercial banks and non-banks. Today, it is the total amount of a currency that is either in general circulation in the form of banknotes or in the deposits held at the central bank – commonly known as reserve balances (Graph B1, top panels).

Although w-CBDC would not impact the size of the central bank's balance sheet, it would change its composition (Graph B1, bottom panels). In the context of PoC1, financial intermediaries "pay" for their w-CBDC in the RTGS system with a transfer from their account to a dedicated technical account. The balance of this account mirrors the overall amount of outstanding w-CBDC and hence of the w-CBDC liability on the central bank balance sheet. Equivalent accounting takes place for financial intermediaries, which record reserve balances and w-CBDC on the asset side of their balance sheet. Issuance increases w-CBDC and reduces reserve balances, and redemptions do so vice versa. Once issued, w-CBDC is transferred within the DLT platform without affecting the central bank balance sheet. Intraday w-CBDC (issued during the business day and redeemed each night) would not impact the central bank balance sheet or be remunerated.

Graph B1: Stylised balance sheet without and with w-CBDC

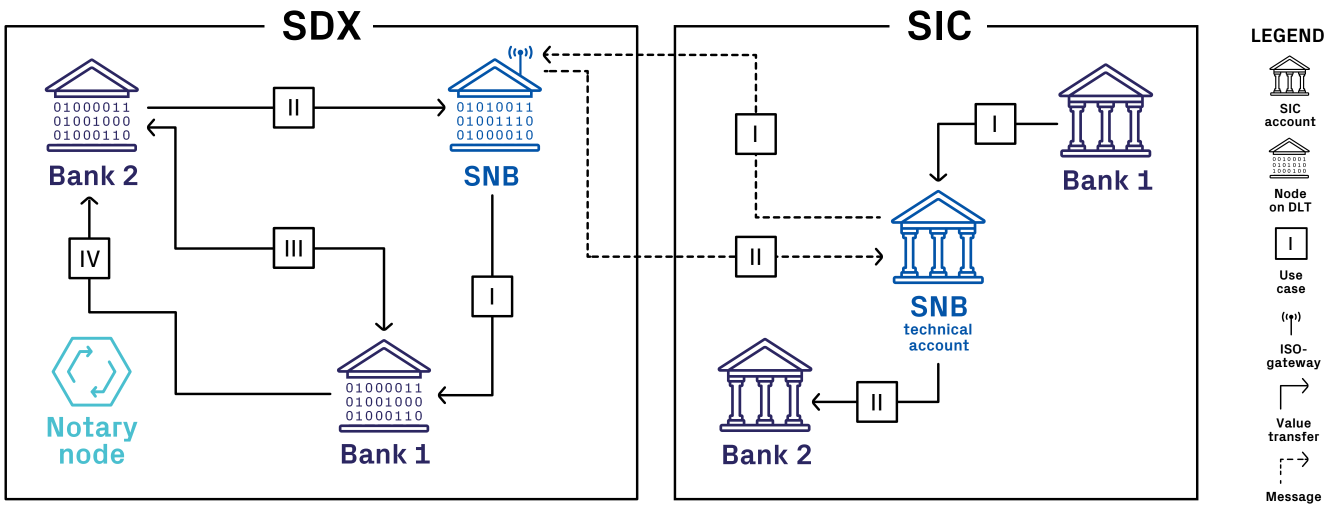


3.4 Solution designs

The solution design sets out how the use cases are tested against the business requirements using the test environments of SDX and SIC. The roles attributed to the SNB (eg technical account and node) were performed solely for the sake of conducting the PoCs in a realistic (albeit experimental) setup for a central bank.

PoC1 (Graph 4) begins with the issuance of w-CBDC (use case I). A commercial bank (Bank 1) initiates the issuance by transferring funds from its SIC account to an SNB technical account in SIC. This triggers an ISO 20022 message from SIC to the SNB node in SDX. A custom ISO gateway translates the message into SDX-specific language. Upon receipt of the translated message, the SNB node issues the equivalent amount of w-CBDC to the Bank 1 node, with the notary node validating the transaction. Once w-CBDC exists on the platform, Bank 1 can conduct on-exchange and OTC DvP transactions with Bank 2 (use case III) in addition to w-CBDC free-of-delivery payments to Bank 2 (use case IV). State changes to the ledger stemming from the transactions are signed and time-stamped by the notary node.

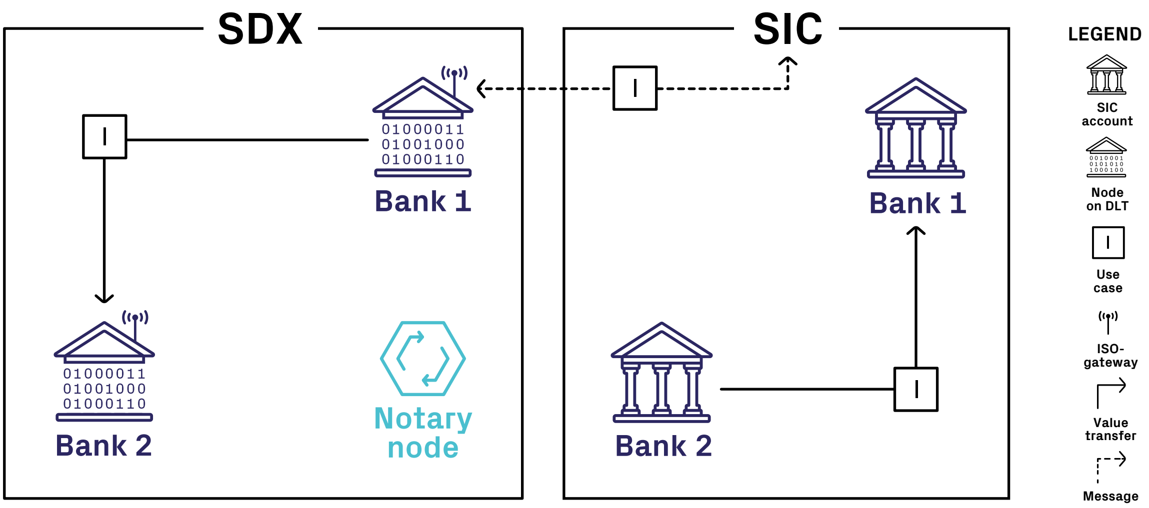
Graph 4: Solution design for DvP settlement in w-CBDC (PoC1)



PoC1 ends with the redemption of w-CBDC (use case II). The Bank 2 node sends a redemption request to the SNB node, which verifies the authenticity of the w-CBDC and forwards the redemption and blocking request to the notary node. After the notary node has successfully signed the blocking request, the SNB node sends an ISO message to the SNB technical account in SIC, instructing it to transfer funds to Bank 2. Once the SNB node has received confirmation of the transfer in SIC, the blocked w-CBDC holdings cannot be used in further transactions by updating their status to “old”.

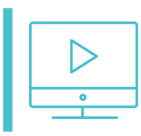
In PoC2, the bilateral settlement of an OTC transaction (Graph 5) is initiated by Banks 1 and 2 in SDX.[13] If the instructions entered by Banks 1 and 2 match, a blocking request is automatically triggered for the tokenised assets. Upon the successful blocking of tokenised assets with Bank 1, the blocking is confirmed by the system, which triggers a third-party payment instruction. A third-party payment instruction is an SIC functionality that instructs the SIC system to transfer SIC balances – here, from Bank 2 to Bank 1. Upon successful payment, an ISO message from the SIC system is sent to the SDX system, which triggers the transfers of the tokenised assets from Bank 1 to Bank 2. By design, the message exchange is through the seller of tokenised assets – here, Bank 1. As in the case of PoC1, an ISO gateway translates the ISO 20022 messages into SDX-specific instructions and vice versa. Throughout the transaction, state changes to the ledger must be signed by the notary node.

Graph 5: Solution design for DvP settlement in SIC balances (PoC2)



3.5 Implementation and testing

To evaluate the use cases (Section 3.2) and demonstrate that the business requirements (Section 3.3) were met, 22 test cases were executed. They were conducted in the SIC and SDX test environments and documented in videos and protocols. Besides use cases, system functionalities were also evaluated, including: (i) end-of-day and beginning-of-day processing; (ii) reconciliation within and across SDX and SIC; and (iii) execution of transactions inside and outside of business hours and with sufficient and insufficient balances. Three selected use cases are illustrated in short videos, which are available online.



[13] It was not possible to test multilaterally settled, on-exchange transactions in PoC2 without developing additional functionality in SIC. As specified in the business requirements of PoC2, the objective was to test against the production SIC.

4. Functional and legal findings

Project Helvetia PoCs build upon similar experimentations by several other central banks (Annex A) and provide novel and policy-relevant insights.

Three factors are behind the new insights. First, the functional requirements of the PoCs were close to those of a production environment, including interdependences with upstream (trading) or downstream systems (banking systems), adding realism. Second, Project Helvetia directly contrasted interoperability between traditional and DLT-based infrastructures, identifying their respective benefits and challenges. Finally, in several instances, realistic business requirements made the solution designs more challenging, with a view to digging deeper in terms of potential policy and legal implications. Examples of such challenging requirements:

- The issuance, transfer and redemption of w-CBDC could be embedded in the existing Swiss civil law framework.
- Changes to the existing operational functions of the Swiss RTGS system were not permitted.
- w-CBDC was not required to be redeemed at the end of the business day. Hence, the practicalities of how to pay (negative) interest on w-CBDC had to be addressed in the PoC.
- w-CBDC was issued (in the test environment) as a distinct central bank liability that would emerge on the central bank balance sheet.[14]

The PoCs show that it is feasible to settle tokenised assets in central bank money. One PoC utilises a w-CBDC, the other links to the existing RTGS. Comparing the two reveals different benefits and challenges (Table 1). Overall, w-CBDC that allows central bank money to exist within an FMI seems to provide more functionalities. Yet issuing a new form of base money (ie w-CBDC) also leads to bigger operational challenges and raises policy and governance questions that central banks will need to consider prior to issuance. Project Helvetia also demonstrates that w-CBDC could be issued and transferred in line with both the existing Swiss legal concepts and the new DLT legislation. Legal assessments may obviously differ in other jurisdictions.

4.1 Functional findings

w-CBDC on a DLT platform signifies opportunities and efficiency gains for settlement in tokenised securities. The on-ledger w-CBDC issued in this experiment existed overnight, making it easier to implement and execute overnight or longer-term smart contracts. A w-CBDC supports atomic multilateral settlement with no time lag, as it can be blocked by the

[14] In other central bank experiments, the digital central bank money was introduced in the form of tokenised depository receipts, ie a claim on reserves in a segregated account at the central bank.

notary node on the DLT platform (along with securities) simultaneously with trading orders.[15] Overall, having tokenised cash and assets on a single DLT platform simplifies the settlement of transactions and supports a broad variety of use cases. However, issuing a w-CBDC is likely to require significant changes to the processes and operations of a central bank and raises significant policy questions (Section 5).

In comparison, linking the DLT platform to the RTGS system is straightforward from a central bank operational and policy perspective. As third-party FMIs (such as CSDs) already settle their cash leg via RTGS systems, central banks will not have to address major new policy questions regarding such arrangements. Hence, only minor adjustments are likely to be necessary. However, linking to the RTGS may limit the functionality and potential provided by the DLT platform. Specifically, many RTGS systems (eg SIC) would not allow atomic multilateral settlement as in PoC1 (w-CBDC), as they (i) settle transactions sequentially, often including a queuing mechanism in case of insufficient balances, and (ii) do not allow simultaneous blocking of balances across multiple parties.

The different benefits and challenges of w-CBDC and the RTGS link were accentuated by the PoC designs. Notably, the business requirement for PoC2 excluded any functional changes to SIC. If the functionality of the RTGS system could be adapted, then multilateral DvP settlement might be possible through the RTGS (although this might raise new policy and governance questions).

Table 1: Comparison of w-CBDC and RTGS-link PoCs

	PoC1, w-CBDC	PoC2, RTGS link
Benefits	**w-CBDC "on ledger" enables the full functionalities of SDX's DLT platform:** ▪ Execution of programmable business logic ("smart contracts") ▪ Atomic multilateral settlement	**An RTGS link:** ▪ Does not raise major new legal or policy questions, as central bank money always remains in the RTGS system ▪ Would require only minor adjustments to the central bank's business processes
Challenges	**Issuing a w-CBDC:** ▪ Raises numerous legal and policy questions ▪ Requires substantive adjustments to the central bank's business processes	**No w-CBDC "on ledger" limits functionalities of the SDX platform:** ▪ Limited execution of smart contracts involving reserve balances ▪ Atomic multilateral settlement of DvP transactions not feasible with RTGS link due to the current setup of SIC (sequential settlement, queuing mechanism, lack of simultaneous blocking mechanism)

[15] The notary node signs and time-stamps all transactions on the platform and can thus attest that w-CBDC has not been spent when a bank seeks to redeem it for reserve balances. While an assessment of the notary node was not part of the project, testing showed that a key governance decision for a central bank issuing w-CBDC would be determining control of the notary node (Annex C provides more technical detail).

4.2 Legal assessment

A clear, transparent and enforceable legal basis is a necessary element of any payment, clearing, and settlement system.[16]

The legal assessment undertaken within this project focuses on the use, in particular the transfer, of w-CBDC under applicable Swiss private laws. Other legal aspects, such as regulatory or tax issues, as well as the competence of the central bank (here the SNB) to issue w-CBDC or the status of legal tender, were not part of the assessment.

The in-depth legal assessment shows that both w-CBDC and the RTGS link allow robust and final settlement of SDX transactions in central bank money. The use of an RTGS link closely resembles today's settlement arrangement and does not in principle raise any major new questions or risks from a civil law perspective. The issuance, transfer and redemption of w-CBDC, however, gave rise to several novel legal questions in the context of PoC1. Ultimately the current Swiss legal framework was found to be able to ensure both robust ownership rights and finality of transfer (for a detailed assessment, see Annex D).

From a civil law perspective, the legal basis for the issuance and redemption of w-CBDC would consist of an agreement governed by Swiss private laws between the participants of the DLT platform and the issuer of w-CBDC, ie the SNB. As such, holders of w-CBDC would have a direct claim on the SNB, just as in the case of SIC balances. Within SDX, w-CBDC would be transferred under civil law by means of a payment instruction pursuant to the provisions of the Swiss Code of Obligations (CO).[17]

In 2021, new legal provisions introducing the concept of ledger-based securities are expected to enter into force in Switzerland ("DLT legislation"). Under this legislation, w-CBDC could be structured and issued as a ledger-based security. As a ledger-based security, the w-CBDC token would embody the claim against the SNB, and the claim passes to the receiver of the transfer simultaneously with the transfer of the token (rather than the token representing a payment instruction, as is the case under current law). As a consequence, the w-CBDC transaction can be executed peer-to-peer, ie without the involvement of an intermediary.

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[16] See CPMI (2017), Sections 3.3.2 and 3.3.3, for a discussion of legal settlement finality and legal risks in a DLT context. Settlement finality is the irrevocable and unconditional transfer of an asset or financial instrument, or the discharge of an obligation by the FMI or its participants in accordance with the terms of the underlying contract.

[17] Article 466 et seq, CO.

5. Policy considerations

Project Helvetia highlights several policy questions for central banks. These questions relate mainly to the issuance of w-CBDC in PoC1. As with the legal considerations above, PoC2 closely resembles today's settlement arrangement and hence raises no fundamentally new policy questions.

The focus of these policy questions is on the implications of providing central bank money for the settlement of tokenised assets on the SDX platform, and not on the impact of the SDX platform or the tokenisation of assets and DLT on the current financial market infrastructure. Moreover, the policy considerations from the PoCs depend on the solution design for these PoCs, so they cannot be generalised unconditionally. The policy implications of issuing a w-CBDC will strongly depend on the chosen w-CBDC design options. For example, (i) if an intraday-only – instead of permanent, as in PoC1 – w-CBDC were to be issued by the central bank, this could have potentially fewer policy implications; (ii) if the access to w-CBDC were wider than to reserve balances (as defined by the central bank access policy), additional policy implications could arise.

5.1 Monetary policy

The primary goal of most central banks is to ensure price stability, taking into account economic activity. To achieve this objective, central banks intervene in financial markets using different monetary policy instruments. Today, most central banks implement monetary policy via the money, foreign exchange or bond markets.

Issuance of a w-CBDC as designed in PoC1 is likely to have only a small impact on the efficacy of monetary policy implementation. The PoC design leaves the outstanding amount of central bank money unchanged, does not alter the eligibility for or access to reserve balances, and ensures one-to-one convertibility between w-CBDC and RTGS balances. However, the introduction of w-CBDC could potentially lead to some segmentation of the money market, which could negatively affect the efficiency and liquidity of the money market. Segmentation could be an issue if different money markets were to emerge for w-CBDC and RTGS balances and if the exchange between the two markets exhibits frictions. Potential drivers include the lack of a marketplace for w-CBDC, different money market conventions for settlement and diverging regulatory treatment. For foreign exchange and bond markets, w-CBDC as designed in PoC1 should have no direct impact.

5.2 Financial stability

As part of their mandate, the majority of central banks have a policy objective to ensure, promote or contribute to the stability of the financial system. A key responsibility concerns the robustness of financial market infrastructures and, in particular, payment systems.

Central bank money settlement contributes to financial stability by avoiding credit and liquidity risk on the settlement asset. However, the issuance of w-CBDC in PoC1 raises some new considerations. w-CBDC may expand the use of central bank money for FMIs. It allows settlement in central bank money without the direct involvement of the central bank accounts and may therefore make access operationally easier for FMIs. Access to central bank money involves complex policy trade-offs (CPSS (2003)). Yet, all other things being equal, broader access to central bank money for FMIs is beneficial for financial stability.

The role of the central bank in financial intermediation and the two-tiered banking system are unaffected by the issuance of w-CBDC, unless access criteria are revised as part of the issuance. Thus, concerns about negative financial stability implications such as digital bank runs or an altered role of the central bank in the financial systems – which are often raised in the context of general purpose CBDC – are mitigated to the largest extent.

The availability of w-CBDC would require participants to manage their central bank money balances on two systems (and potentially more). This increases the complexity of liquidity management for participants (although this is also true if a private coin is used).

5.3 Payments policy

Central banks have an implicit or explicit mandate to promote safe and efficient payments. A core instrument by which central banks carry out their public policy objectives is providing the safest form of money to banks, businesses and the public: central bank money.

In payments policy too, issuing a w-CBDC raises more fundamental payments policy questions than an RTGS link. By issuing a w-CBDC, a central bank provides an alternative way to make payments in central bank money. While choice is generally good, spreading payments traffic across multiple platforms does potentially reduce economies of scale in operating payment systems, driving up overall cost.

Issuing a w-CBDC on a specific private sector platform potentially favours one provider relative to the others. There are several ways to mitigate this. One way could be for the central bank to issue w-CBDC on any DLT platform which fulfils a given set of criteria determined by the central bank. Another way could be for the central bank to issue w-CBDC on a common platform for private sector FMIs to link to.

Central banks will have to investigate how governance arrangements for payment systems might need to evolve when moving from a centralised to a decentralised settlement infrastructure. In a centralised settlement infrastructure, central banks typically operate the payment system. In the case of issuing w-CBDC on a private sector platform, central banks act as issuer and a priori have only limited control over the platform. Hence, central banks need to put in place governance measures to assert their interests. For example, central banks may want to be able to set eligibility criteria for w-CBDC. Otherwise, entities without an RTGS account may get access to w-CBDC by participating on a DLT platform, which would involuntarily expand access to digital central bank money. Beyond the access question, central banks need to consider the extent to which they want to have (intraday and end-of-day) transparency and intervention possibilities on the settlement in w-CBDC on the DLT platform.

SDX trades settle instantaneously on a gross basis, rather than deferred and net. All trades on SDX will hence need to be prefunded. This could lead to an increase in the liquidity required for settlement, potentially leading to a higher demand for intraday liquidity from the central bank. However, gross settlement could lead to higher liquidity demand irrespective of whether the settlement takes place in w-CBDC, through the RTGS link or through a private coin fully funded by central bank money (eg SDX coin).

While PoC2 does not raise any new payments policy issues, it yields important insights for further developing the RTGS system. To facilitate interoperability with DLT platforms such as SDX, eg to enable atomic multilateral settlement, RTGS systems would require the functionality to block balances across multiple accounts. The latest generation of central bank payment systems – so-called instant payment systems – also allow parallel settlement (instead of sequential settlement) and might be better suited to accommodate the "all-or-nothing" logic required by atomic multilateral settlement.

6. Conclusion and next steps

Project Helvetia successfully tested multiple ways to settle tokenised assets in central bank money. In the experiment, the SNB issued a Swiss franc w-CBDC onto a near-live DLT test platform and – together with SIX – built a link from the Swiss RTGS test system to the same platform. Detailed analysis showed that settlement in both approaches is legally feasible and robust.

Linking a DLT-based securities settlement system to an RTGS resembles the current setup in many ways. Yet what an RTGS link provides in terms of simplicity, it lacks in terms of potential benefits. The w-CBDC PoC demonstrates that an integration of tokenised central bank money and securities could enable functionality not possible with a link. This is worth exploring further. That said, a w-CBDC raises both practical and policy issues for a central bank. Project Helvetia explores some, but not all of these, and work continues.

The next step is to seek a deeper understanding of the practical complexities and policy implications of issuing w-CBDC. The idea is to introduce even more realism into the project and to explore in more detail the different trade-offs that different design choices yield.[18] Initially, Project Helvetia will proceed in two complementary directions, to:

- deepen the project, addressing further functional, operational and policy questions related to the issuance of w-CBDC, such as the integration of w-CBDC into core banking systems and the implications for the wider payments ecosystem; and

- broaden future involvement in the project to explore the functioning of a w-CBDC across borders and with a diverse set of participants.

In the recent past, central bank discussions of w-CBDC were largely hypothetical and theoretical. Yet, as private operators of FMIs drive innovation and new technologies, central banks are proving increasingly practical in thinking about how they can continue to meet their responsibility to provide a safe and liquid settlement asset. Within a central bank, those implementing monetary policy, monitoring financial stability and operating payment systems will all need to continue to work together on a coherent strategy to prepare for the future.

Finally, this project is a tangible example of the value of cooperation as change gathers pace across the globe. Private system operators and central banks alike have an incentive to preserve the use of safe money. Overcoming the policy challenges and technical obstacles will involve collaboration, including across borders. The BISIH Swiss Centre, SIX and the SNB are all committed to progressing in this spirit, including to share the findings of the future work publicly.

[18] Important aspects that were not considered include: linking to other necessary internal systems (eg the core banking system); the participants in the payment and securities settlement systems (ie financial intermediaries); liquidity management; operational questions of scale, speed and security; regulatory monitoring; and the impact on cross-border or cross-currency payments.

References

Australian Securities Exchange (ASX) (2017): "ASX selects distributed ledger technology to replace CHESS", press release, 7 December.

Bank of Canada (2018): *Jasper Phase III: securities settlement using distributed ledger,* October.

Bank of France (2020): Central bank digital currency experiments with the Banque de France – call for applications package, 27 March.

Bank of Thailand (2019): *Inthanon Phase II – enhancing bond lifecycle functionalities & programmable compliance using distributed ledger technology,* July.

Bank of Thailand & Hong Kong Monetary Authority (2020): *Leveraging distributed ledger technology to increase efficiency in cross-border payments,* January.

Bech, M, J Hancock, T Rice, A Wadsworth (2020): *On the future of securities settlement,* BIS Quarterly Review, March.

Committee on Payments and Market Infrastructures (CPMI) (2019): *Wholesale digital tokens,* December.

Committee on Payments and Market Infrastructures (CPMI) (2017): *Distributed ledger technology in payment, clearing and settlement,* February.

Committee on Payments and Market Infrastructures & International Organization of Securities Commissions (CPMI-IOSCO) (2012): *Principles for Financial Market Infrastructures,* April.

Committee on Payments and Market Infrastructures & Markets Committee (CPMI-MC) (2018): *Central bank digital currencies,* March.

Committee on Payment and Settlement Systems (CPSS) (2003): *The role of central bank money in payment systems,* August.

The Depository Trust & Clearing Corporation (DTCC) (2020): *Project ION case study,* May.

Deutsche Bundesbank (2018): *Blockbaster – final report,* 25 October.

European Central Bank & Bank of Japan (ECB-BoJ) (2018): *Stella – securities settlement systems: delivery-versus-payment in a distributed ledger environment,* March.

Federal Council (2019): "Federal Council wants to further improve framework conditions for DLT/blockchain", press release, 27 November.

G7 Working Group on Stablecoins (2019): *Investigating the impact of global stablecoins,* October.

Group of central banks (2020): *CBDCs: foundational principles and core features,* joint report by the Bank of Canada, the European Central Bank, the Bank of Japan, Sveriges Riksbank, the Swiss National Bank, the Bank of England, the Board of Governors of the Federal Reserve System and the Bank for International Settlements, October.

Monetary Authority of Singapore (MAS) (2018): *Ubin Phase III – delivery versus payment on distributed ledger technologies.*

Shabsigh, G, T Khiaonarong and H Leinonen (2020): "Distributed ledger technology experiments in payments and settlements", *IMF Fintech Note,* 24 June.

SIX (2020): *Annual Report 2019.*

Acronyms and abbreviations

ASX	Australian Securities Exchange
BIS	Bank for International Settlements
BISIH	BIS Innovation Hub
BoJ	Bank of Japan
CBDC	central bank digital currency
CCP	central counterparty
CO	Swiss Code of Obligations
CPMI	Committee on Payments and Market Infrastructures
CSD	central securities depository
DLT	distributed ledger technology
DTCC	The Depository Trust & Clearing Corporation
DvP	delivery-versus-payment
ECB	European Central Bank
FINMA	Swiss Financial Market Supervisory Authority
FinMIA	Swiss Financial Market Infrastructure Act
FMI	financial market infrastructure
IOSCO	International Organization of Securities Commissions
MAS	Monetary Authority of Singapore
MC	Markets Committee
OTC	over-the-counter
PoC	proof of concept
PvP	payment-versus-payment
RTGS	real-time gross settlement
SDX	SIX Digital Exchange
SIC	Swiss Interbank Clearing
SNB	Swiss National Bank
w-CBDC	wholesale central bank digital currency

Annex A: DvP and tokenisation – experiments by central banks

Central banks have conducted or announced experiments related to the settlement of tokenised assets using wholesale CBDC, or using linked central bank payment systems for settlement.[19]

European Central Bank and Bank of Japan – Stella Phase II (March 2018)
In Phase II of Project Stella, the European Central Bank (ECB) and the Bank of Japan (BoJ) evaluated different approaches to DvP in a DLT environment, namely single-ledger and cross-ledger DvP. They concluded that cross-ledger DvP arrangements may entail certain complexities and risks, and could also impact transaction speed and lead to the blockage of liquidity (ECB-BoJ (2018)).

Bank of Canada – Jasper Phase III (October 2018)
In Phase III of Project Jasper, the Bank of Canada together with other market players evaluated the DvP settlement of tokenised securities and digital cash on a DLT platform, achieving instant finality on the platform. The prototype was modelled resembling the existing system, and the participants in the project concluded that operational cost savings and reduced back office reconciliation efforts might be demonstrated if there was a more fundamental departure from the existing settlement processes and market infrastructure ecosystem (Bank of Canada (2018)).

Deutsche Bundesbank – Blockbaster (October 2018)
In Project Blockbaster, the Deutsche Bundesbank together with Deutsche Börse Group developed a prototype for a DLT-based transfer of tokenised securities and tokenised cash. They successfully demonstrated the DvP settlement on the blockchain. The Bundesbank also concluded that both of the prototypes developed in the project would be able to fulfil performance requirements for the use case (Deutsche Bundesbank (2018)).

Monetary Authority of Singapore – Ubin Phase III (November 2018)
In Phase III of Project Ubin, the Monetary Authority of Singapore (MAS) together with other market players evaluated DvP settlement between different ledgers for tokenised Singapore government securities and tokenised cash depository receipts issued by MAS. The DvP settlement models developed allow settlement cycles to be compressed and post-trade settlement processes to be simplified. In addition, the project shows that smart contracts could enable the consistent and coherent implementation of rights and obligations (MAS (2018)).

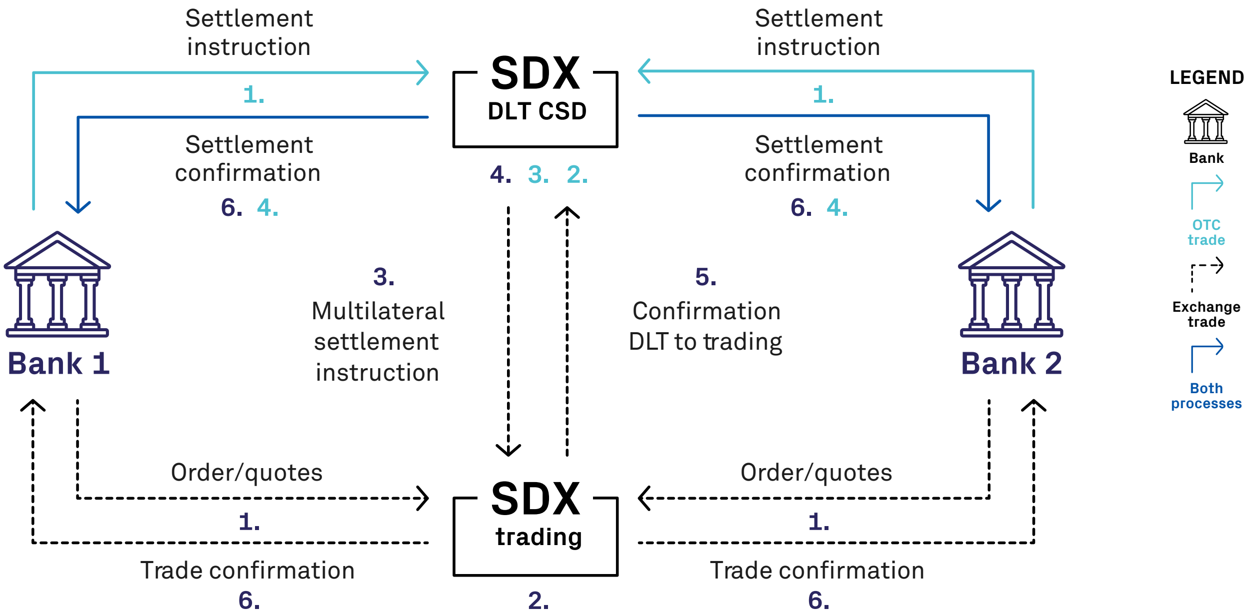
Bank of Thailand – Inthanon Phase II (July 2019)
In Phase II of Project Inthanon, the Bank of Thailand evaluated DvP settlement for tokenised bonds in interbank market trading and in repo markets against cash tokens issued by the Bank of Thailand. The project adopted a single-ledger model for tokenised cash and securities. Besides successfully executing the DvP, the project also demonstrated the potential of smart contracts to streamline operational processes and increase efficiency (Bank of Thailand (2019)).

Bank of France – experiments (ongoing)
The Bank of France has announced that it will conduct experiments that will evaluate payment in euro wholesale CBDC against the delivery of listed or unlisted financial instruments and tokenised assets (Bank of France (2020)).

[19] Shabsigh et al (2020) provide a broader overview of DLT experiments in payments and settlements.

Annex B: Exchange trade flow and OTC trade flow at SDX

Graph 6: Trade flows at SDX



Process steps for an exchange trade:

1. Participants send their buy and sell orders to the SDX trading system.
2. The SDX trading system searches for matching buy and sell orders and matches them using a continuous auction market model.
3. The SDX trading system creates and transmits to the SDX node a single multilateral settlement instruction that contains all tokenized securities and cash movements that need to be settled, between the two or possibly more participants involved in the auction.
4. The SDX node interacts with the nodes of all the participants involved in the multilateral settlement instruction, validating that the participants nodes have sufficient asset and cash tokens:
   a. If that is the case, the respective balances (SDX private coins and tokenized assets) are credited and debited by updating the ledgers in the respective nodes.
   b. In case of insufficient balances (even with only one of the involved parties), the multilateral settlement instruction is not processed as a whole, and the trading system is informed accordingly. The orders are then captured and inserted again in the next auction, except for the orders of the participant(s) with insufficient balances, which are excluded.
5. The SDX node notifies the SDX trading system, which updates the status of all relevant orders to executed.
6. The SDX trading system notifies the participants of the execution of their orders and the SDX CSD participants are notified of the settlement of their trades using ISO messaging.

Process steps for an OTC trade:

1. Participants send settlement instructions to the SDX DLT CSD infrastructure for the delivery, respectively the receiving of a certain quantity of tokenized assets versus some amount of SDX private coin with another participant on a specific settlement date.
2. The participant node checks whether it has already received a request from the other participant‘s node that corresponds to the instruction it has just received. If so, it verifies that sufficient balances are available, and – if so - creates, signs, and sends a request to the node of the other participant.
3. The node of the other participant checks whether its account contains a sufficient amount of the other token.
4. If that is the case, the two nodes update their respective databases with the new balances and notifications of the settlement are provided using ISO messaging.

Annex C: Selected aspects of the SDX technical infrastructure

Privacy and anonymity

Two features of the SDX technical infrastructure (Corda DLT) ensure a level of privacy and anonymity similar to that of existing FMIs. First, transactions in Corda are shared with participants on a need-to-know basis. Second, the notary node does not know the content of the transaction when signing and time-stamping – that is, it does not check the validity of transactions. However, it ensures that proposed state changes to the system do not concern old states, thereby avoiding double-spending (Box C).

CorDapps

The specific SDX business logic is a set of bespoke applications building on Corda technology, so-called CorDapps. CorDapps are distributed software applications that can provide any functionality required. For example, the application software defines how ledger entries can be changed and by whom. On the SDX platform for going live, the application software is entirely created, maintained, controlled and deployed by SDX. Nodes can execute multiple CorDapps, depending on the respective roles assigned to them in the SDX DLT infrastructure (ie role as issuer agent in addition to role as member).

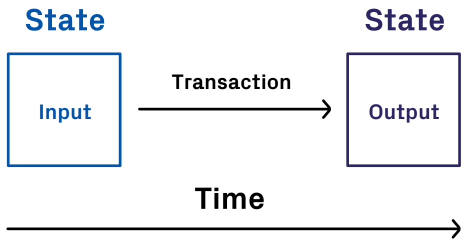
Identity and key management

Access to SDX's DLT is determined by issuing SDX-approved certificates that allow for unique identification of a participant as the dedicated counterparty to a transaction, ensuring the four pillars of trust: confidentiality (only the parties interacting in a trade or transaction are aware of it); authenticity (a counterparty is who it claims to be); integrity (any information exchanged with the counterparty has not been tampered with); and non-repudiation (a counterparty is not able to deny its participation in a transaction).

Box C: Functioning of the notary node in SDX and the prevention of double-spending

The notary node centralises the consensus mechanism in the SDX DLT environment and prevents double-spending. To understand its functioning, the concepts of a state, an input, a transaction and an output in Corda are essential. A state is an unalterable object, a "fact" at a given point in time (eg Bank A owns X amount of tokenised assets). Transactions update the ledger by marking existing ledger states as old (the inputs) and producing new ledger states (the outputs), as illustrated in Graph C1.

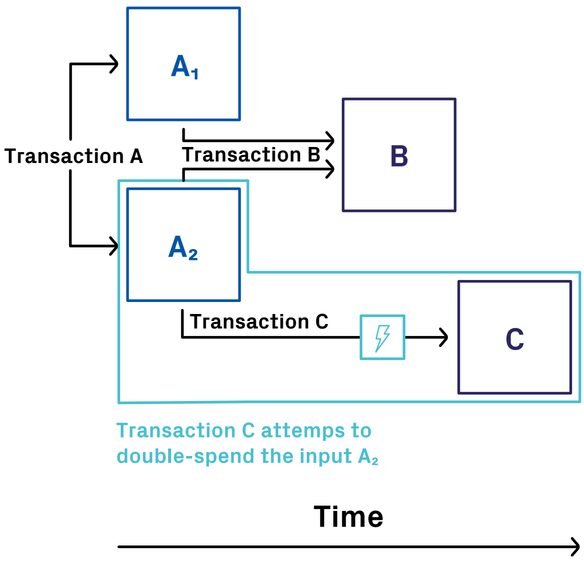
Graph C1: Input state, transactions and output state



Based on three transactions (A, B and C), the example below illustrates how the notary node prevents double-spending (Graph C2). Transaction A creates two output states, which serve as input states in future transactions (A_1 and A_2). Transaction B consumes the two outputs of transaction A. Now, the party which triggered transaction B attempts to also use A_2 in transaction C (attempted double-spending). The notary node detects that output A_2 has been spent and refuses to sign transaction C.

To verify whether a state has been consumed, the notary node checks the State ID, which is unique to any given state. The State ID consists of the hash value of the transaction details and is labelled "latest" if it is the latest state, and "old" if it has been consumed. The notary node maintains a database with all state IDs.

Graph C2: Double-spending attempt



Annex D: Legal assessment of issuance, redemption and transfer of w-CBDC

The issuance and redemption of w-CBDC do not in principle pose major legal issues. In essence, the legal basis for the issuance and redemption of w-CBDC from a civil law perspective lies in an agreement between the participants in the DLT platform and the issuer of w-CBDC, ie the SNB. From a legal perspective, w-CBDC would not constitute a new form of claim against the SNB but only an alternative representation of said claim against the SNB by means of a new technology. Therefore, the parties are in principle free to define their respective rights and obligations regarding the w-CBDC within the existing and established legal framework.

The legal assessment therefore focuses on the use, and more specifically on the transfer, of w-CBDC, both under applicable Swiss civil laws as of 2020, and under the new Swiss DLT legislation expected to enter into force in 2021. The analysis indicates that both legal frameworks can allow for a legally robust and final transfer of w-CBDC on the SDX platform.

From a purely civil law perspective (without taking into consideration any regulatory, business or tax issues), the issuance of w-CBDC under the new DLT legislation is considered to entail fewer risks than under the applicable Swiss civil laws. However, this conclusion is based on the assumption that all mandatory legal requirements for the establishment of ledger-based securities are met. It will for either option be important that the point in time of legal finality set by the system's rules coincides with the point in time of technical finality on the SDX platform.

Transfer of w-CBDC under applicable Swiss civil law

The legal analysis concluded that, under applicable Swiss civil law, legal robustness of a w-CBDC token transfer can be achieved only if the respective token is categorised as a payment instruction pursuant to the pertinent provisions of the Swiss Code of Obligations (CO).[20] In this case, the token can be regarded as representing an instruction by the first holder, and each subsequent holder respectively, to the issuer of the w-CBDC to debit the payor's node on the ledger with a certain amount, and to credit the same amount to the node of a beneficiary. Thereby, the token does not embody or represent a legal title. It is merely an electronic information carrier or the carrier of a declaration of intent that can be transferred in accordance with the legal provisions on payment instructions, ie without having to observe any specific form requirements (eg physical transfer of possession or written assignment).

The technical design of the SDX infrastructure allows for the transfer of w-CBDC in line with the provisions of the law on payment instructions. The transfer occurs by analogy with the traditional account-based process of debiting and crediting book money, whereby SDX/SNB and the notary node it operates are involved in every transaction. The transfer of w-CBDC in PoC1 hence occurs on the basis of a payment instruction and relies on the well established and robust legal concept that has traditionally been used for cashless payments.

[20] Article 466 et seq, CO.

Table 2: Legal qualification of the technical steps for the transfer of w-CBDC on SDX under the applicable Swiss legal provisions on payment instructions

	Necessary technical steps for the transfer of w-CBDC on the SDX infrastructure	Legal qualification under the applicable Swiss legal provisions on payment instructions
1.	Payor sends the transaction to the notary node.	Payment instruction according to Article 466 et seq, CO.
2.	Notary node, controlled by SDX/SNB, checks that none of the input states has previously been spent/notarised.	Receipt of the payment instruction by the SNB occurs with the transmission of the instruction from the payor to the notary node by the system.
3.	Notary node marks the input states as spent in its database. Notary node signs the transaction and sends an instruction to the system to update all states accordingly to credit the node of the beneficiary. This step marks the technical finality of the transaction: it is processed automatically by the system and can no longer be stopped or revoked by the participants.	The execution of the transaction is initiated by the SNB with the notary node signing the transaction and the transmission to the system.
4.	The system, controlled by SDX/SNB, updates the payor's database by debiting his node on the ledger with the relevant amount.	Provided the SDX infrastructure qualifies as payment system,[21] and unless the rules of the system provide for an earlier point in time,[22] step 4 marks the point in time as of which the transaction becomes legally irrevocable and reaches settlement finality for legal purposes. As a result, the transfer of w-CBDC is irrevocable and unconditional and not susceptible to being unwound following the bankruptcy or insolvency of the payor. At the same time, this step generates a claim in favour of the beneficiary vis-à-vis the SNB for the value of w-CBDC.
5.	The system, controlled by SDX/SNB, sends information to the beneficiary's node to update its database.	Technical process with no implications from a legal perspective.
6.	SDX/SNB performs various checks prior to updating the database on the beneficiary's node.	Technical process with no implications from a legal perspective.
7.	SDX/SNB records a new state, ie it credits the value of w-CBDC to the beneficiary's node.	This step marks the point in time by which the transaction becomes legally irrevocable and reaches settlement finality for legal purposes in the event the SDX infrastructure does not qualify as payment system.[23] The crediting of w-CBDC to the beneficiary's node on the ledger by the system constitutes the SNB's acceptance of the payment instruction vis-à-vis the beneficiary. This in turn generates a claim in favour of the beneficiary vis-à-vis the SNB for the value of w-CBDC. From a legal point of view, the execution of the payment instruction is concluded with this step.

21 Article 470, paragraph 2bis, CO.
22 Article 89, Financial Market Infrastructure Act (FinMIA).
23 Article 470, paragraph 2, CO.

For finality in SDX, the technical functions of the platform and the respective legal processes do not run fully in parallel (Table 2). Specifically, there is a time gap between the point in time at which the transaction reaches technical finality (step 3), and settlement finality for legal purposes (step 4 if the SDX infrastructure qualifies as payment system, and step 7 if the SDX infrastructure does not qualify as payment system). This may lead to a scenario in which the payor would legally have the right to revoke its payment instruction vis-à-vis the SNB, but is factually prevented from doing so, as the transaction has already reached technical finality. Since steps 2 to 7 are executed in one logical step by the SDX infrastructure without further contribution by the participants, it is, however, very unlikely that the aforementioned conflict will actually materialise. In addition, potential residual legal risks stemming from an inconsistency between technical and legal settlement finality should be excluded if the rules of SDX define the legal finality of transactions to coincide with the notary node signing the transaction and transmitting it to the system for processing.[24]

Transfer of w-CBDC under the new Swiss DLT legislation

Under the new Swiss DLT legislation,[25] expected to enter into force in 2021, w-CBDC could alternatively be structured and issued as a so-called ledger-based security ("Registerwertrecht"). As a ledger-based security, the token embodies the holder's claim vis-à-vis the issuer, as opposed to serving merely as a means of information. A ledger-based security can be transferred peer-to-peer on the ledger without the involvement of an intermediary. The underlying right passes to the beneficiary simultaneously with the ownership of the token.

For the establishment of w-CBDC under the new DLT legislation, the securities ledger must meet the following requirements as prescribed by the newly introduced provisions of the CO: [26]

- Technological processes give the creditor, but not the obligor, power of disposal over the respective rights.
- Integrity is secured through adequate technical and organisational measures, such as joint management by several independent participants, to protect it from unauthorised modifications.
- The content of the rights, the functioning of the ledger and the registration agreement are recorded in the ledger or in linked accompanying data.
- Creditors see relevant information and ledger entries, checking the integrity of the ledger contents relating to themselves without intervention by a third party.

The new DLT legislation does not specifically govern the point in time when a disposal of ledger-based securities becomes legally effective. Rather, it leaves it up to each system, in accordance with its respective functionality, to define said moment. However, the CO does contain a provision concerning finality in the event of participant default.[27] Specifically, a participant's disposal over a ledger-based security is legally binding and effective against third parties if (i) it is made prior to the participant's bankruptcy, property distrainment or authorisation of a debt restructuring moratorium; (ii) it has become irrevocable under the rules of the securities ledger or another trading facility; and (iii) it is recorded in the securities ledger within 24 hours. If one of the above conditions is not met, the transaction is not considered effective against third parties, meaning that the respective ledger-based security becomes part of the participant's bankruptcy estate.

[24] Article 470, paragraph 2bis CO; and Article 89, FinMIA.
[25] Federal Council (2019).
[26] Article 973d, paragraph 2, draft CO.
[27] Article 973f, paragraph 2, draft CO.

Contributors

Steering group

BIS	Benoît Cœuré, Head, BIS Innovation Hub Morten Bech, Head, BIS Innovation Hub Swiss Centre
SNB	Andréa M Maechler, Member of the Governing Board Thomas Moser, Alternate Member of the Governing Board Sébastien Kraenzlin, Head of Banking Operations Peter Thüring, Deputy Head of IT
SIX	Jos Dijsselhof, Chief Executive Officer, SIX Thomas Zeeb, Head, Securities & Exchanges, SIX Tim Grant, Head, SDX Michael Montoya, Managing Director, SIC

Project group

BISIH Swiss Centre	Philipp Haene, Adviser Henry Holden, Adviser Oliver Sigrist, Adviser
SNB	Nino Landerer, Project Lead, Banking Operations Benjamin Müller, Deputy Project Lead, Banking Operations Fabio Wieser, BISIH Coordinator, Banking Operations Romain Baeriswyl, Expert Group, Economic Affairs Milena Di Cioccio Müller, Expert Group, Legal Jürg Mägerle, Expert Group, Financial Stability Erich Baronchelli, Expert Group, IT Björn Freivogel, Expert Group, IT
SIX	Mathias Studach, Project Lead, SDX Cyrill Blöchlinger, Project Manager, SDX Philippe de Toffol, Business Architect, SDX Martin Frick, Project Lead, SIC (until September 2020) Timo Pfahl, Project Lead, SIC (from September 2020) Roman Locher, Deputy Project Lead, SIC