PROJECT JURA

Cross-border settlement using wholesale CBDC

BANQUE DE FRANCE
EUROSYSTÈME

BIS Innovation Hub

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FOREWORD

Project Jura was conducted by the Banque de France, the BIS Innovation Hub and the Swiss National Bank in collaboration with a group of private sector firms based on an open call for applications. It is part of a series of wholesale CBDC experiments initiated by the Banque de France in 2020 and continues the experimentation conducted by the Swiss National Bank and the BIS Innovation Hub under Project Helvetia.

"With the great success of Jura, the wholesale CBDC experiment programme launched by the Banque de France in 2020 is now completed. Jura demonstrates how wholesale CBDC can optimise cross-currency and cross-border settlements, which are a key facet of international transactions."

Sylvie Goulard, Deputy Governor, Banque de France

"Project Jura confirms that a well designed wholesale CBDC can play a critical role as a safe and neutral settlement asset for international financial transactions. It also demonstrates how central banks and the private sector can work together across borders to foster innovation."

Benoît Cœuré, Head, BIS Innovation Hub

"As a small open economy, Switzerland requires efficient and robust cross-border payment and settlement arrangements. Project Jura explores how distributed ledger technology can be successfully leveraged to map out how future-proof cross-border settlement between financial institutions could look like."

Andréa M Maechler, Member of the Governing Board, Swiss National Bank

REMARKS FROM THE PRIVATE SECTOR CONSORTIUM

Accenture, Credit Suisse, Natixis, R3, SDX and UBS with support from Heuking, Linklaters and OCTO Technology are proud to have participated in Project Jura together with the Banque de France, BIS Innovation Hub and the Swiss National Bank. Project Jura advances further the frontier of knowledge about DLT-enabled wholesale CBDC (wCBDC) and is expected to make a significant contribution towards laying the foundations for possible wCBDC adoption.

wCBDC is about diversification in payments and the emergence of an alternative central bank medium of exchange that may offer new functionalities and utilities. It promotes safe and efficient settlement of domestic and international financial transactions.

Our consortium recognises the opportunities brought by wCBDC to meet actual and future payment and settlement needs and facilitate the emergence of more direct international financial relations. The foreign exchange market in particular could be a key beneficiary by migrating towards outright exchanges in wCBDC where trade execution, payment and settlement may become a single transaction, while mitigating risks and increasing efficiency. This could help to reduce the fragmentation of liquidity in correspondent banking globally and to promote the international use of central bank money.

The use of wCBDCs in the context of securities transactions could also enhance the operational efficiency of primary and secondary markets and extend the safety of central bank money to new financial market infrastructures, freeing up bank capital.

The group greatly values continued public-private partnerships in working towards developing solutions and improving the global financial ecosystem.

Project Jura advances the private sector's commitment towards the use of CBDC for payments and settlements. It builds on projects such as *Helvetia* with the Swiss National Bank and the BIS Innovation Hub, *E-krona* with the Riksbank, *Khokha2* with the South African Reserve Bank, *Jasper* with the Bank of Canada and *Ubin* with the Monetary Authority of Singapore.

EXECUTIVE SUMMARY

The global financial system needs better and more diverse payment and settlement arrangements to meet current and future demands. Existing arrangements are often slow, expensive, potentially risky and complex as they involve numerous intermediaries and financial market infrastructures. A new generation of infrastructures, based on distributed ledger technology (DLT), is emerging and several central banks are exploring use cases for wholesale central bank digital currency (wCBDC) with a view to potentially supporting a safe tokenised financial ecosystem. These novel technology-driven approaches may offer greater choice and competition in terms of cross-border payments and settlements, also by broadening access to central bank money for regulated financial institutions.

Project Jura explored the direct transfer of euro and Swiss franc wCBDCs between French and Swiss commercial banks on a single DLT platform operated by a third party. Tokenised asset and foreign exchange trades were settled safely and efficiently using payment versus payment (PvP) and delivery versus payment (DvP) mechanisms. The experiment was conducted in a near-real setting, used real-value transactions and met current regulatory requirements.

Issuing wCBDC on a third-party platform and giving non-resident financial institutions direct access to central bank money raises intricate policy issues. Jura explores a new approach including subnetworks and dual-notary signing, which may give central banks comfort to issue wCBDC on a third-party platform and to provide non-resident financial institutions with access to wCBDC.

The project complements the ongoing G20 work on cross-border payments. Specifically, it contributes to the building blocks on PvP adoption, multilateral platforms and CBDC by extending access to the safety of central bank money for cross-border settlements. The proposed solution design not only addresses existing deficiencies but could also open up new approaches to conducting international financial transactions, including foreign exchange, securities and other financial instruments.

Jura is a public-private collaboration involving the Banque de France (BdF), the BIS Innovation Hub (BISIH) Swiss Centre and the Swiss National Bank (SNB) and a consortium led by Accenture and comprising Credit Suisse, Natixis, R3, SIX Digital Exchange (SDX) and UBS. It leveraged the test environment of a DLT-based Swiss licensed exchange and central securities depository for tokenised assets (SDX), and a newly developed issuance platform for unlisted commercial papers under French law (the Digital Asset Registry, DAR). Both platforms are based on Corda by R3.

It is essential for central banks to remain up-to-date with technological developments that could potentially enhance the functioning of the financial system. Project Jura shows how collaboration between central banks and the private sector, based on an open call for applications, can shed light on the potential of tokenisation and DLT in cross-border settlements. While the experiment demonstrates the technical feasibility of using wCBDCs for this purpose, the decision will rest with individual central banks as to whether and how they will further explore the issuance of wCBDC.

ACRONYMS, ABBREVIATIONS AND TERMS

Atomic settlement	Transfer of two transaction legs so that the transfer of one transaction leg occurs if and only if the transfer of the other transaction leg also occurs
Banks	Shorthand for financial institutions or multinational financial services firms with access to an account at a central bank
BdF	Banque de France
BIS	Bank for International Settlements
BISIH	BIS Innovation Hub
CBDC	Central bank digital currency
Corda	DLT technical platform by R3
CPMI	Committee on Payments and Market Infrastructures
Cross-border settlement	The exchange of assets or currencies between financial institutions domiciled in different jurisdictions
CSD	Central securities depository
CLS	Continuous Linked Settlement
DAR	Digital Asset Registry – a new DLT based registry for tokenised commercial papers issued under French law (NEU CP)
DLT	Distributed ledger technology
DvP	Delivery versus payment
FINMA	Swiss Financial Market Supervisory Authority
FoP	Free of payment
FSB	Financial Stability Board
FX	Foreign exchange
MC	Markets Committee
Hash time locked contract	A smart contract that facilitates transfers across ledgers
NEU CP	Negotiable European Commercial Paper. In the experiment, the NEU CP is issued in tokenised form.
Offshore settlement	The exchange of domestic assets or currencies between foreign financial institutions abroad
PvP	Payment versus payment
Resident and non-resident banks	Resident bank refers to banks with some specified form of authorised establishment within a domestic currency area, including banks with local branches but primarily regulated elsewhere. By contrast, non-resident banks have no such establishment (CPSS (2003)).
RTGS	Real-time gross settlement – individual and transaction-by-transaction settlement for interbank payment systems
SDX	SIX Digital Exchange – a licensed exchange and CSD for tokenised assets
SIC	Swiss Interbank Clearing – Swiss RTGS system
SNB	Swiss National Bank
SWIFT	Society for Worldwide Interbank Financial Telecommunications – a global provider of financial messaging services
TARGET2	Trans-European Automated Real-time Gross Settlement Express Transfer System – the euro zone's RTGS system. In the report, depending on the context, "TARGET2" stands either for the TARGET2-Banque de France, French component of TARGET2 or the overall TARGET2 system.
Tokenised assets	Assets issued on a DLT based platform or network
wCBDC	Wholesale CBDC

CONTENTS

1 INTRODUCTION

The global financial system needs better and more diverse settlement arrangements to meet current and future demands. Existing arrangements are often slow, expensive, potentially risky and complex as they involve numerous intermediaries and financial market infrastructures. A new generation of infrastructures, based on distributed ledger technology (DLT), is emerging and several central banks are exploring use cases for wholesale central bank digital currency (wCBDC) with a view to potentially supporting a new tokenised financial ecosystem.[1] These novel technology-driven approaches may offer greater choice and competition in terms of cross-border payments and settlements, also by broadening access to central bank money for regulated financial institutions.

In June 2021, Banque de France (BdF), the BIS Innovation Hub (BISIH), and the Swiss National Bank (SNB) announced that they would test the use of wCBDC for cross-border payments and settlements together with a private sector consortium comprising Accenture (lead), Credit Suisse, Natixis, R3, SIX Digital Exchange (SDX) and UBS, with support from Heuking, Linklaters and OCTO Technology. Known as Project Jura, the experiment is part of a BdF series of wCBDC experimentations announced in a public call for applications in March 2020 (BdF (2020))[2] and it continues the work on wCBDC by SNB and BISIH that started with Project Helvetia (BIS, SIX and SNB (2020)).

The BdF experimentation programme aims to (i) show how "traditional" interbank settlement could be carried out using wCBDC based on different technologies; (ii) identify the benefits of wCBDC for the current ecosystem of market and payment infrastructures and clarify how wCBDC could foster financial innovation; and (iii) analyse what effects a wCBDC might have on financial stability, monetary policy and the regulatory environment (BdF (2020)).

Project Jura investigates cross-border settlement with euro and Swiss franc wCBDCs and a French tokenised financial instrument on a third-party DLT-based platform. The aim is to conduct payment-versus-payment (PvP) and delivery-versus-payment (DvP) settlement between French and Swiss banks and to explore how the safety of central bank money can be extended across borders. To this end, the experiment deploys a new architecture that may give central banks comfort to issue wCBDC on a foreign third-party platform and to provide non-resident financial institutions[3] with access to wCBDC. By allowing different wCBDCs to co-exist on a single platform, cross-border payments can flow directly between financial institutions. Moreover, adding other tokenised assets opens up new possibilities for cross-border settlement of FX, securities and other financial instruments.

1 DLT refers to the technological infrastructure and protocols that allow simultaneous access, validation and immutable record updating to a synchronised ledger that is used by a network of participants that may spread across multiple entities and/or locations. In the context of payment, clearing and settlement, DLT enables entities, to carry out transactions without necessarily relying on a central authority to maintain a single "golden copy" of the ledger (CPMI (2017)).

2 The application by the consortium was one of eight selected out of 40 applications submitted (BdF (2021)).

3 Resident and non-resident financial institutions or banks involved in the Jura experiment are all regulated.

With its new approach, Project Jura complements earlier and ongoing projects that explore the use of wCBDC in cross-border payments and settlements. Such experiments include Jasper-Ubin (Bank of Canada and Monetary Authority of Singapore (2019)), Stella (European Central Bank and Bank of Japan (2019)), Inthanon-Lionrock (Bank of Thailand and Hong Kong Monetary Authority (2020)), Aber (Saudi Central Bank and Central Bank of the UAE (2020)) Dunbar (BISIH (2021a)), mCBDC bridge (BISIH (2021b)), and the series of experiments by the Banque de France (BdF (2021)).

The experiment was conducted using real-value transactions within the existing legal and regulatory frameworks – not in a "regulatory sandbox". This added significant complexity but also realism to the project. It helped to test different technologies in a near-real setting and shed light on technical limitations as well as legal and regulatory challenges. To ensure compliance with existing legal and regulatory frameworks, the wCBDCs issued on the SDX test platform did not represent a direct central bank liability for the purpose of the experiment. Final settlement of the cash leg was achieved only in the corresponding RTGS systems.[4]

This report describes the Jura experiment and presents the findings and lessons learned. It is organised as follows. Section 2 outlines current challenges in cross-border settlement. Section 3 then details the experiment transactions and solution design. Policy considerations are outlined in Section 4 and Section 5 concludes.

4 Project Helvetia Phase I showed that CHF wCBDC could be issued and transferred under Swiss law on SDX. In such a setup, holders of the wCBDC would have a direct claim against the SNB, which would allow a final settlement to be achieved on the SDX platform (BIS, SIX and SNB (2020)).

2 CROSS-BORDER SETTLEMENT

Cross-border transactions are numerous and valued in trillions of euros every day. For example, in 2019, SWIFT processed almost 7 billion cross-border messages (CPMI (2019)) and FX turnover alone was USD 6.6 trillion per day in April 2019 (BIS (2019)).

Cross-border settlement is broadly understood as the exchange of assets or currencies between financial institutions domiciled in different jurisdictions. Offshore settlement is the exchange of domestic assets or currencies between foreign financial institutions abroad.[5] Typically, cross-border settlements rely either on international arrangements (eg CLS for settling FX transactions and International Central Securities Depositories (ICSDs) for settling cross-border securities transactions) or networks of intermediaries leveraging domestic arrangements (eg correspondent banking). Currently, efficient international arrangements cover only a limited range of currencies, assets and participants. Consequently, cross-border settlements can involve greater risks than domestic ones, and are often costly, slow and opaque.

DvP and PvP reduce settlement risk and support global financial stability. Yet in 2019, foreign exchange trades settled globally with PvP protection were estimated to be below 40%, down from 50% in 2013 (Bech and Holden (2019)). The safety of central bank money underpins systemically important settlement (CPMI-IOSCO (2012)). However, only a few international arrangements settle in central bank money and its use in cross-border settlement could be increased. Further, reducing the number of intermediaries connecting investors and issuers across borders could help investors to ascertain their rights and claims vis-à-vis the ultimate issuer (Micheler (2014)).

The G20 has made enhancing cross-border payments a priority (FSB (2020)). Nineteen building blocks for overcoming challenges in cross-border payments have been identified (CPMI (2020)). Project Jura contributes to building blocks 9 (PvP settlement), 17 (multilateral platforms) and 19 (CBDC). Initiatives are also under way to improve cross-border settlements. One example is the ongoing initiative to establish a regional settlement intermediary to integrate bond markets among Asian economies (Asian Development Bank (2020)).

wCBDC could open up new ways to improve cross-border settlement (CPMI (2021)). Various approaches have been identified and explored in experiments. Central banks could deploy wCBDCs in separate domestic platforms with interoperability linking them. Alternatively, multiple wCBDCs could be combined in a "corridor network" where central banks agree on a common governance for the network (eg mCBDC bridge (BISIH (2021b)). Project Jura adopted a new approach by providing non-resident institutions with intraday access to wCBDC and deploying two wCBDCs on a third-party platform.

5 For example, in Project Jura a French and a Swiss commercial bank exchanged a French tokenised commercial paper against euros in a cross-border settlement; and two Swiss banks exchanged the same financial instrument in an offshore settlement.

3 THE EXPERIMENT

Project Jura involved the issuance of intraday wCBDCs and tokenised commercial paper, settled cross-border between France (Natixis) and Switzerland (Credit Suisse and UBS) on a DLT platform. For the purposes of the experiment, the French bank was considered a non-resident for CHF wCBDC and the two Swiss banks were non-residents for EUR wCBDC. Yet as all three were participants on the same platform and had been granted direct access to the intraday wCBDCs, they were able to directly hold and transfer wCBDCs. The issuance of wCBDCs was triggered by transferring funds to central banks in the respective RTGS systems either directly or through correspondents

All transactions were real value, with terms, conditions and prices (rates) agreed ex ante on an over-the-counter (OTC) basis. Rather than employing a "regulatory sandbox" for the experiment, the transactions took place under the existing legal and regulatory frameworks of France and Switzerland. Settlement finality was achieved by corresponding transfers in the RTGS systems and the Digital Asset Registry (DAR) (ie the registry for the tokenised commercial paper).

Original development work was required for the experiment in several dimensions. That included a "dual-notary signing" capability developed by R3 as part of Corda and its integration into the SDX test platform. Additionally, a new financial instrument issuance platform, the DAR, was developed by OCTO Technology and Accenture with guidance and input from Natixis. Finally, a set of rulebooks governing the real-value transactions of the experiment between the commercial banks was drafted by Heuking and Linklaters. The rulebooks governed the legal relationships between the private sector participants and the financial commitments arising from the settlement of the euro and Swiss franc transactions in the experiment.

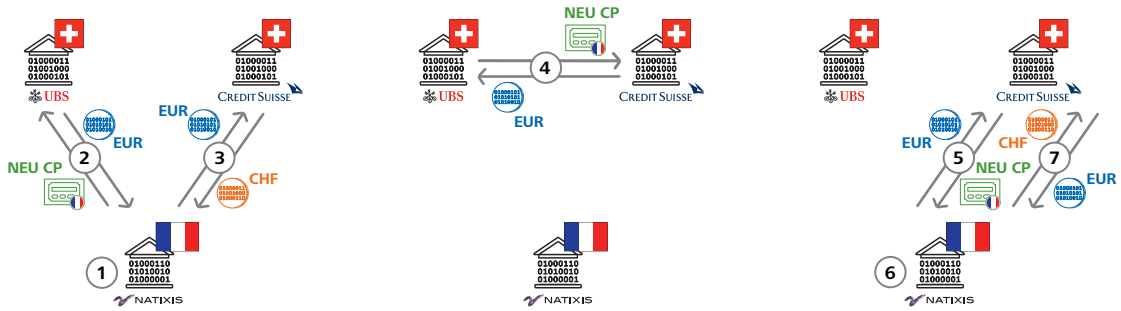
Transaction flow

The actual experiment took place over three days in November 2021. On day one, Natixis issued EUR 200,000 worth of tokenised commercial paper (NEU CP) and sold it to UBS. UBS paid for the NEU CP with intraday EUR wCBDC. Also, on day one, Credit Suisse exchanged CHF wCBDC against EUR wCBDC with Natixis. On day two, UBS exchanged the NEU CP with Credit Suisse against EUR wCBDC in an offshore transaction. On day three, Credit Suisse returned the NEU CP to Natixis for EUR wCBDC, where it was redeemed. Finally, Credit Suisse exchanged EUR wCBDC against CHF wCBDC with Natixis to return holdings to their positions on day one (Figure 1).

See video

FIGURE 1 – Transaction flow[1]

DAY 1 NEU CP issuance and FX settlement	DAY 2 NEU CP secondary market exchange	DAY 3 Redemption of NEU CP and FX settlement
① Issuance of NEU CP ② Cross-border DvP (NEU CP vs EUR wCBDC) ③ Cross-border PvP (EUR vs CHF wCBDC)	④ Offshore DvP (NEU CP vs EUR wCBDC)	⑤ Cross-border DvP (EUR wCBDC vs NEU CP) ⑥ Redemption of NEU CP ⑦ Cross-border PvP (EUR vs CHF wCBDC)



1 For simplicity, issuance and redemption of EUR and CHF wCBDC are not included here.

Experimental design

The experimental architecture comprised four infrastructure elements: (i) TARGET2; (ii) the SIC system; (iii) the DAR; and (iv) the SDX test platform (Figure 2). The first three enabled the issuance and redemption of wCBDC and tokenised commercial paper and final settlement of instruments. The SDX test platform was where the PvP and DvP exchanges of these tokens took place (Table 1).

FIGURE 2 – Experimental architecture

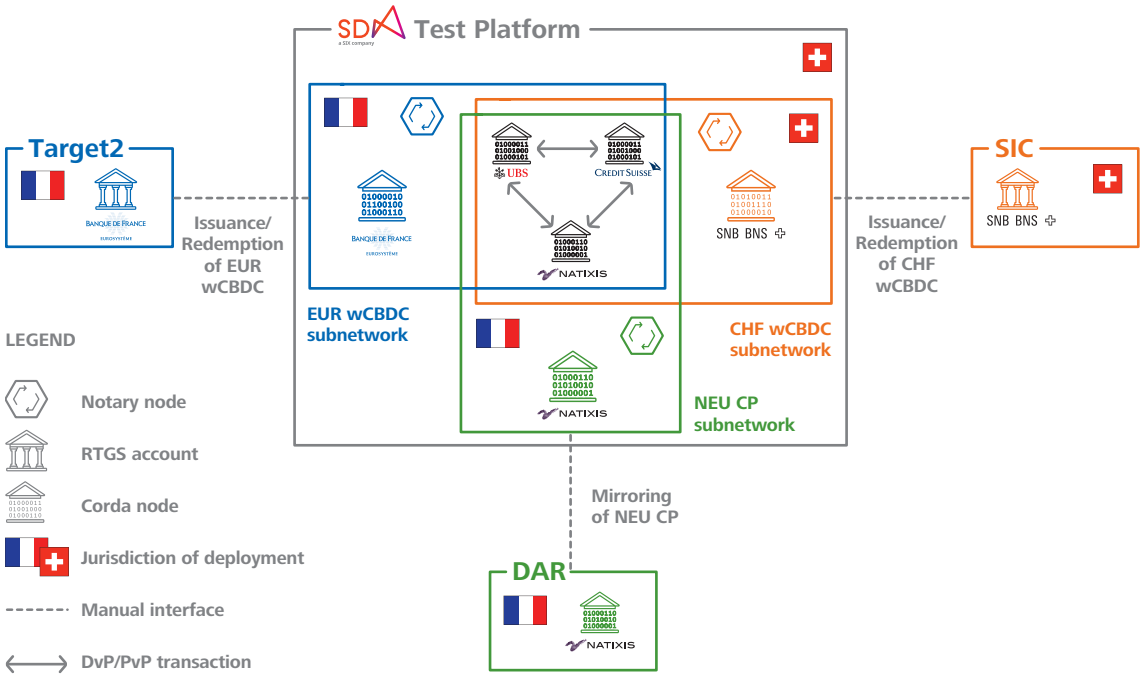


TABLE 1 – Experimental technology, tokenised assets and infrastructures

DLT	**Corda** is the underlying permissioned DLT technical platform for the SDX platform and the DAR. Developed by R3, Corda rests on a decentralised peer-to-peer network of computer nodes. It operates on a need-to-know basis with data shared only between the counterparties of a transaction. Communications at a protocol level are invisible to uninvolved members of the platform. Yet observer nodes can be deployed to view transaction data, aiding compliance with legal and regulatory requirements. Corda's consensus model is based on validation and uniqueness. In the validation process each counterparty independently confirms that the transaction adheres to the shared business rules. Corda uses a notary node to ensure transaction uniqueness by signing and time-stamping the transaction, avoiding double-spending. Corda's privacy design avoids use of large-scale computing resources, keeping energy consumption to a level comparable with that of conventional database applications.
Tokenised assets	**Swiss franc (CHF) wCBDC** is issued by the SNB on the SDX test platform against blocked balances in a technical account in the SIC system. Similarly, **euro (EUR) wCBDC** is issued by the BdF on the SDX test platform against blocked balances in a technical account in TARGET2. Credit Suisse, UBS and Natixis all have intraday access to wCBDC in EUR and CHF. Natixis uses a Swiss correspondent for the transfer in the SIC system, while Credit Suisse and UBS use French correspondents for transfers in TARGET2.
	Negotiable European Commercial Paper (NEU CP) is a short-term debt instrument with a maturity of one year or less, issued in accordance with the French monetary and financial code and the laws and regulations of the French negotiable debt securities market. In the experiment, Natixis issued a single unrated and unlisted real-value tokenised zero-coupon NEU CP with a 10-day maturity and a notional amount of EUR 200,000 at a yield consistent with the Natixis credit spread. The instrument is issued at a premium and reimbursed at par as part of Natixis's programme for unrated NEU CPs, as mentioned in the Information Memorandum submitted to BdF. It is issued and recorded on the DAR in accordance with French law in registered form ("au nominatif").
Infrastructures	**SIC** and **TARGET2** are the real-time gross settlement (RTGS) systems in which electronic central bank money is transferred today. They are used in the experiment to underpin the CHF and EUR wCBDC issued on the SDX test platform with real value.
	The **SDX test platform** is the test environment of SDX, a Swiss exchange and central securities depository (CSD) for tokenised assets licensed by the Swiss Financial Market Supervisory Authority (FINMA). In November 2021, SDX issued the first digital bond in a fully regulated environment.[1] SDX provides issuance, settlement, asset servicing and custody for tokenised assets. For the experiment, transactions were processed using DvP, PvP and free-of-payment (FoP) methods on a transaction-by-transaction basis.
	The **Digital Asset Registry** (DAR) records the holdings and transfers of the NEU CP and allows the owner, type, characteristics, notional amounts and quantities of financial instruments held to be identified. Natixis is administrator, operator and registrar of the DAR and acts as gateway to the SDX platform. The three commercial banks (Credit Suisse, Natixis as issuer and UBS) as well as the administrator (Natixis) have a node on the platform. Natixis also has access to an observer node to monitor all transactions and holdings for the NEU CP on the DAR. The DAR is compliant with French financial regulation under the Ordonnance Blockchain[2], which authorises the use of a DLT platform for the representation and transfer of unlisted financial instruments as an alternative to traditional CSDs.

[1] *www.six-group.com/en/newsroom/media-releases/2021/20211118-six-sdx-digital-bond.html*
[2] *www.legifrance.gouv.fr/loda/id/JORFTEXT000036171908/*

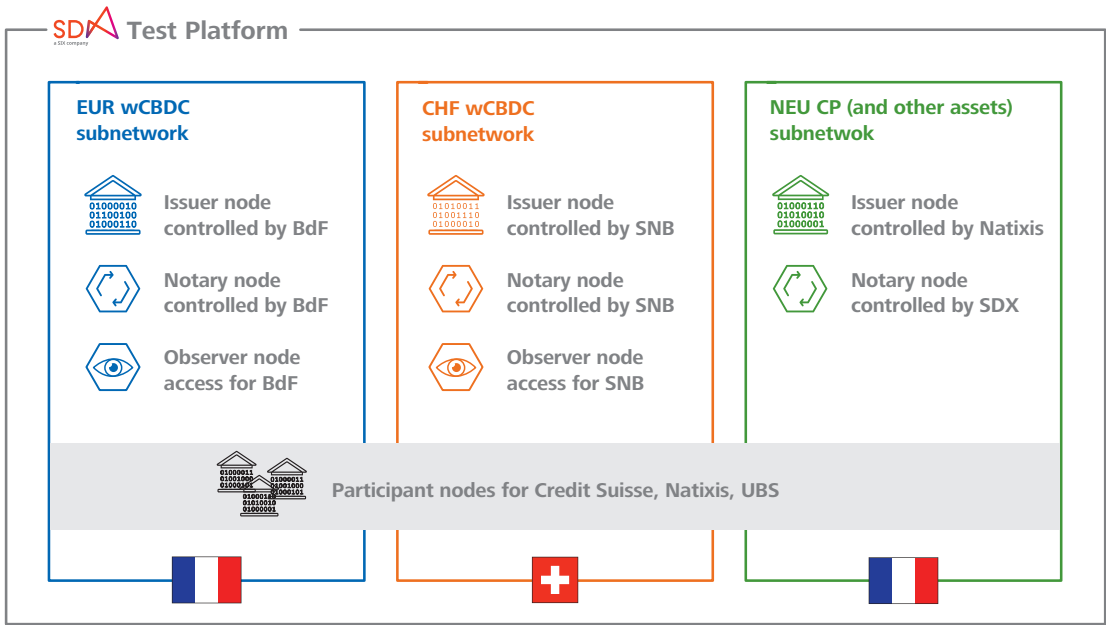
The SDX test platform was configured as follows (Figure 3). The three commercial bank participants (Credit Suisse, Natixis and UBS) each controlled a node on the SDX test platform that could hold and transfer the wCBDCs as well as the tokenised commercial paper. Moreover, the test platform was partitioned into three subnetworks – one for each of the tokenised assets. The EUR wCBDC and the NEU CP subnetworks were deployed on a French cloud-based data centre, and the CHF wCBDC subnetwork ran on a Swiss cloud-based data centre. Each subnetwork contained a unique issuer and notary node. Issuer nodes had sole rights to create (or destroy) tokens on a subnetwork.

In Corda DLT, notary nodes validate transactions. The notary node for the EUR wCBDC was controlled by the BdF, the notary node for CHF wCBDC by the SNB, and the notary node for NEU CP by SDX. Every DvP or PvP transaction required the involvement of two notary nodes, one for each token. The transfer of the two tokens within their respective SDX subnetwork was coordinated by the SDX settlement engine, which incorporated Corda's dual-notary signing capability. As is the case with so-called hash time locked contracts,[6] the dual-notary signing allows assets governed in different subnetworks to be exchanged without requiring the issuers to trust each other or give up control over their assets (see Annex). It ensures that for DvP and PvP either both legs are transferred or none are (ie that transfers are "atomic").[7]

Because notary nodes are not equipped to see the transaction details, an observer node is necessary for central banks to monitor activity for their respective wCBDCs in real-time and reconcile token movements with other systems.

For central banks, the subnetworks enable them to individually control who has access to, and settlement of, their wCBDCs. This is achieved by approving participants at the subnetwork level and maintaining control of the subnetwork notary node.

FIGURE 3 – SDX test platform topology



6 See eg Box C in Bech et al (2020).

7 In addition to being used on a single network (as for Jura), other DLT networks could also use dual-notary signing to enable cross-network settlement. This is a different approach to interoperability, as compared with freezing and mirroring NEU CP on the DAR (akin to a depositary receipt). If mirroring is conducted by the original issuer or a trusted agent, the integrity of the issue can be preserved.

The design provides central banks with the controls that are essential for issuance of wCBDC on a third-party platform, ie being the sole issuer of a wCBDC, sole discretion to allow or remove access to a wCBDC, and monitoring and control of a wCBDC and any settlements.

Technical details

The experiments involved four types of transaction: (i) issuance and redemption of EUR and CHF wCBDC; (ii) primary issuance and redemption of NEU CP on the DAR and the mirroring on the SDX test platform; (iii) DvP on the SDX test platform; and (iv) PvP on the SDX test platform. All transactions were documented in a playbook, describing the detailed process steps for every participant.

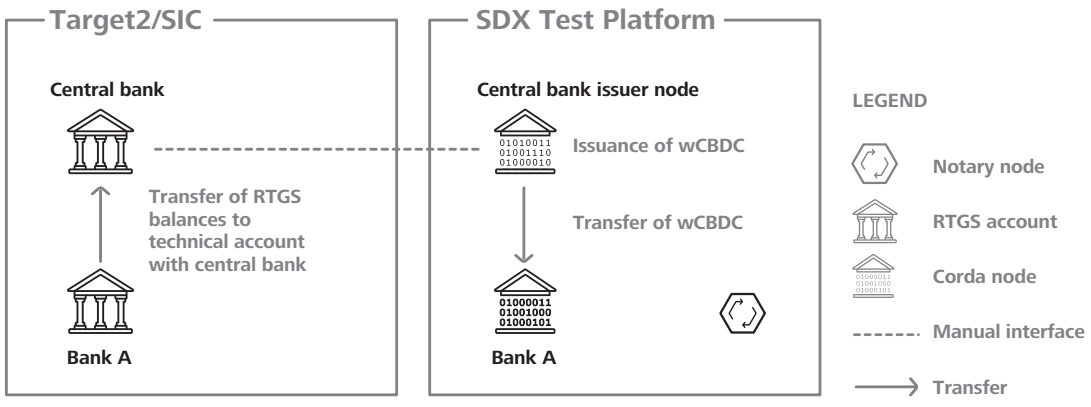
In Project Jura, EUR and CHF wCBDC and the NEU CP token on the SDX test platform had no legal force, meaning that the wCBDCs did not represent a direct central bank liability. While atomic exchanges for the PvP and the DvP were achieved on the SDX test platform, final, real-value settlement occurred in the underlying RTGS systems (TARGET2 and the SIC system) for the wCBDCs and in the DAR for the NEU CP. All settlements on the SDX test platform and the DAR were governed by the rulebooks.

Issuance and redemption of wCBDC

Commercial banks trigger the issuance and redemption of wCBDC by transferring funds to central banks' technical accounts in the RTGS systems (Figure 4).[8] Upon receipt of funds, a central bank creates an equivalent amount of wCBDC in its issuer node on the SDX test platform and signs and time-stamps them with its notary node. wCBDC is then transferred to the commercial bank node.

To redeem wCBDC, a commercial bank transfers it from its node to the central bank issuer node on the SDX test platform. The central bank then destroys the wCBDC, signing and time-stamping this with the central bank notary node. Funds are then transferred from the technical account in the RTGS system to the commercial bank's account or that of its correspondent.

FIGURE 4 – wCBDC issuance



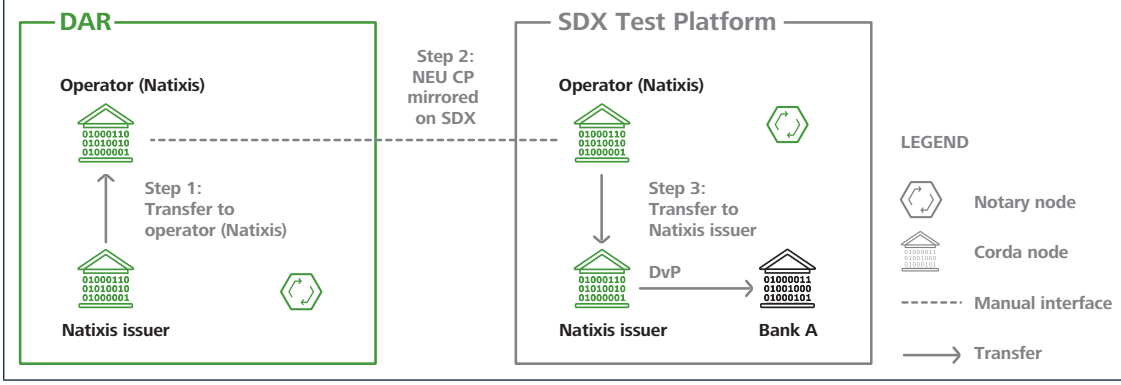
8 If a commercial bank is not a participant in the RTGS system, it relies on a local correspondent bank for the transfer of the RTGS system balances.

NEU CP primary issuance

To issue NEU CP on the DAR, the Natixis issuer node instructs the operator (Natixis) node to create the NEU CP. After creating the NEU CP, the operator (Natixis) node transfers the NEU CP to the Natixis issuer node.

To prepare the primary placement of the NEU CP to Bank A, it is mirrored on the SDX test platform. For this, the Natixis issuer node sends the NEU CP back to the operator node on DAR (Figure 5, step 1). The operator – which acts as gateway between DAR and the SDX test platform – freezes the NEU CP on the DAR and mirrors it on the SDX test platform (Step 2). Afterwards, the mirrored NEU CP is transferred from the operator node to the Natixis issuer node on the SDX test platform in an intra-node free-of-payment (FoP) transfer (Step 3). With that, the primary placement can take place on the SDX test platform with a DvP between the Natixis issuer and Bank A. The redemption follows this process in reverse.

FIGURE 5 – NEU CP primary issuance



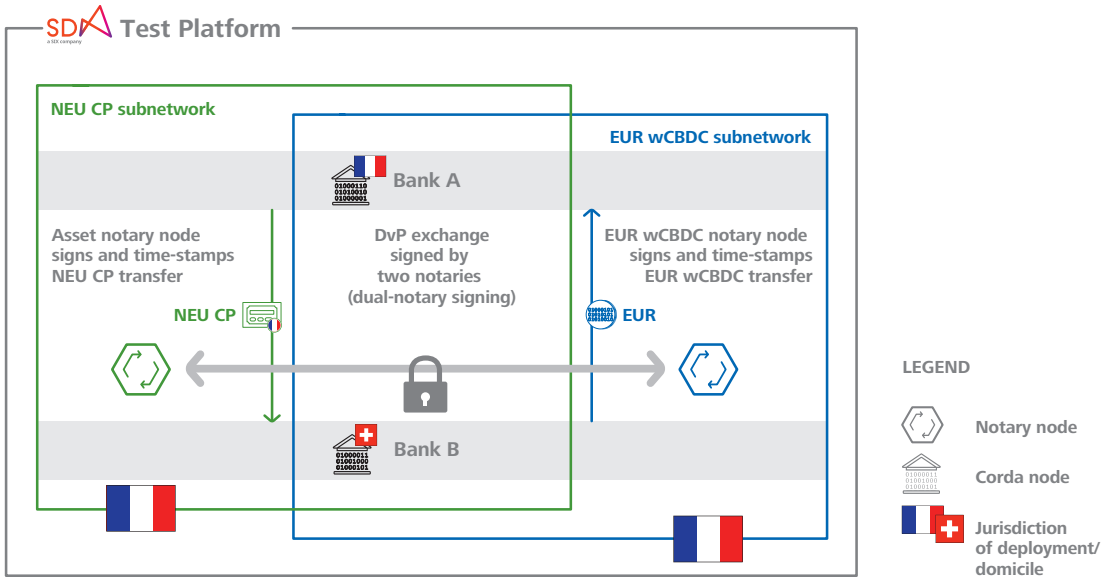
DvP settlement of NEU CP for EUR wCBDC

Exchanging NEU CP for EUR wCBDC in a DvP transaction takes place on the SDX test platform. The exchange is initiated by both counterparties entering the settlement instruction details on the SDX test platform (type of asset, quantity of NEU CP tokens, amount of wCBDC, value date). Once the terms of the DvP have been validated and matched, the transfers of the NEU CP token and the EUR wCBDC are executed automatically, instantaneously and atomically.[9] Specifically, the transfers of both tokens are linked by the SDX settlement engine using the dual-notary signing capability to ensure that either both tokens are transferred or none are (Figure 6). The NEU CP and the EUR wCBDC are transferred in their subnetworks, with both notary nodes signing and time-stamping the transfer.

Final settlement of the delivery and the payment legs occurs in DAR and TARGET2, respectively. After the DvP exchange on SDX, the NEU CP is transferred to the operator node on the SDX test platform, where it is destroyed and the frozen NEU CP on the DAR is unlocked by the operator node and then transferred to the buyer to achieve final settlement. The equivalent process occurs for the cash leg, with the EUR wCBDC redeemed by the BdF, which then transfers the balances in TARGET2 to the seller (either directly or through a correspondent).

9 If one or more counterparties have an insufficient quantity/amount of tokens to deliver, the SDX settlement engine re-attempts settlement dynamically and automatically.

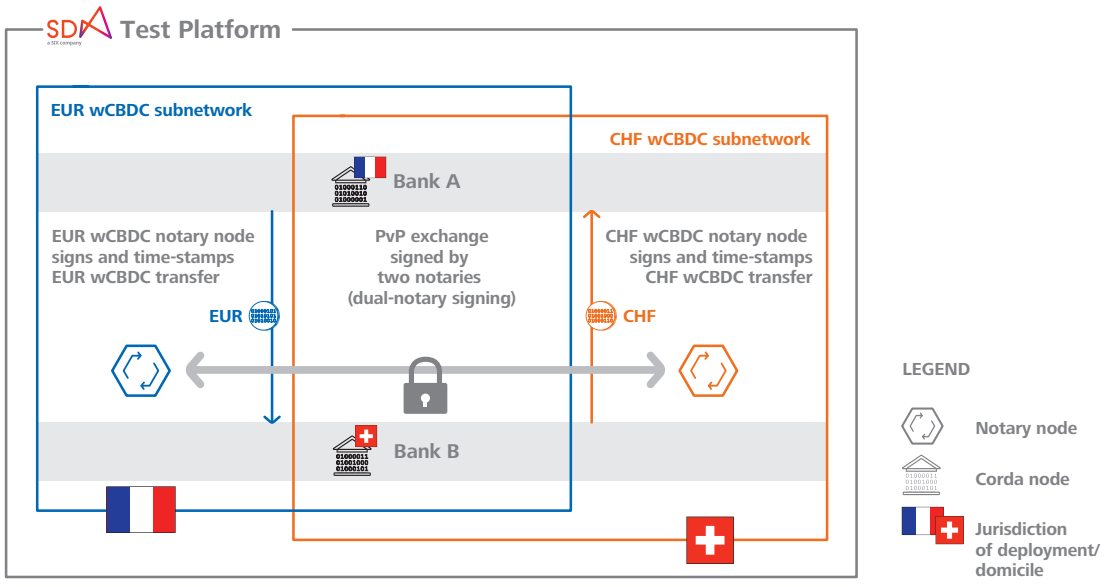
FIGURE 6 – DvP exchange of NEU CP against EUR wCBDC



PvP settlement of EUR wCBDC against CHF wCBDC

In a PvP transaction, EUR wCBDCs are exchanged against CHF wCBDC on the SDX test platform. The PvP is initiated by both counterparties entering settlement instruction details on the SDX platform (currencies, amounts and value date). Once the terms of the PvP have been validated and matched on the SDX test platform, the transfers of the EUR wCBDC and the CHF wCBDC are executed automatically, instantaneously and atomically. The EUR wCBDC transfer is signed and time-stamped by the BdF notary node in the EUR wCBDC subnetwork, and the CHF wCBDC transfer is signed and time-stamped by the SNB notary node in the CHF wCBDC subnetwork. The transfers of both tokens are linked by the SDX settlement engine using the dual-notary signing capability to ensure that either both tokens are transferred or none are (Figure 7). Final settlement of the payments occurs when the counterparties redeem the wCBDC and receive the balances from central banks via the RTGS systems.

FIGURE 7 – PvP exchange of EUR wCBDC against CHF wCBDC



4 POLICY CONSIDERATIONS

The introduction of a wCBDC involves several important design choices, which raises policy considerations with regard to financial stability, monetary policy implementation and access. Such considerations have already been analysed extensively in earlier reports (eg MC-CPMI (2018); BIS (2021) or by previous experiments (eg BIS, SIX and SNB (2020) and BdF (2021)). Hence, the focus here is on where the Jura experiment has provided additional insights.

The EUR and CHF wCBDCs in Jura have two key features: they are "intraday"[10] and directly ("outright") available to non-resident banks.[11]

Early wCBDC projects focused on intraday wCBDC (eg Bank of Canada (2018); Monetary Authority of Singapore (2018); Bank of Canada and Monetary Authority of Singapore (2019)) but more recent experiments have looked at overnight wCBDCs (eg Bank of Thailand (2019); Bank of Thailand and Hong Kong Monetary Authority (2020); BIS, SIX and SNB (2020)).

So far, most practical experiments have investigated access for resident banks only but with Project Jura and the second phase of Project Helvetia (BIS, SIX and SNB (forthcoming)) this has changed, and more experiments are under way (eg Project Dunbar (BIS Innovation Hub (2021a)). Table 2 outlines the type of non-resident access investigated in selected cross-border wCBDC projects.

TABLE 2 – Non-resident bank access in selected cross-border wCBDC projects[1]

		Non-resident banks' access to wCBDC		
		None	Intraday	Overnight
Type of wCBDC	Intraday only	**Jasper-Ubin**[2] **(CAD, SGD)**	**Jura (EUR, CHF)**	
	Overnight	**Inthanon-Lionrock**[3] **(THB, HKD)** **Helvetia I (CHF)**[4]		***Helvetia II*** **(CHF)**[5] ***Dunbar***[6]

[1] *Italics* indicate project or project phase not yet complete.
[2] Bank of Canada and Monetary Authority of Singapore (2019).
[3] Bank of Thailand and Hong Kong Monetary Authority (2020).
[4] BIS, SIX and SNB (2020); in Helvetia I, the same access criteria were assumed for the wCBDC as for the RTGS system; some non-resident banks have access to the Swiss franc RTGS system and hence would be eligible for wCBDC, but the experiment was conducted in a domestic setting.
[5] *www.bis.org/about/bisih/topics/cbdc/helvetia.htm*
[6] *www.bis.org/about/bisih/topics/cbdc/wcbdc.htm*

10 An intraday wCBDC means that there is a mandatory conversion of wCBDC into reserve balances before the value date change in the RTGS system. An alternative approach is to have the wCBDC exist indefinitely on the DLT platform. This is referred to here as "overnight" wCBDC to emphasise that there is no end-of-day conversion, and it would remain on the holder's balance sheet overnight. Nonetheless, an overnight wCBDC can still be converted into reserves at any time at the holder's request.

11 A resident bank refers to banks with some specified form of authorised establishment within a domestic currency area, including banks with local branches but primarily regulated elsewhere. By contrast, non-resident banks have no such establishment (CPSS (2003)).

An intraday wCBDC as in Jura is designed to minimise the impact on central bank policies; nevertheless, adjustments may still be needed. As outlined below, the implications of an intraday wCBDC arrangement for cross-border settlement should be positive for financial stability. Circulating multiple wCBDCs on a single platform, however, will require some coordination between the central banks involved. Central Bank Access policies need to change to accommodate the use of wCBDC by non-resident banks, which may have implications for monetary policy implementation. Access to central bank money by non-residents banks is, however, not a new topic and currently the exception rather than the rule.

Financial stability

A Project Jura-type setup could be conducive to financial stability from three perspectives. First, it should reduce risk, thanks to the increased use of PvP and DvP and the extended use of central bank money. Second, the emergence of a tokenised financial ecosystem could lead to greater competition and diversity and provide operational backup through a larger number of cross-border settlement services. Third, granting non-resident banks access to wCBDC could reduce their need to pre-position funds with correspondent banks, thus simplifying liquidity management and reducing the cost of cross-border transactions.

Monetary policy implementation

In terms of monetary policy implementation, the potential effects of introducing a wCBDC depend in part on whether it is used primarily as a means of payment or as a store of value (eg MC-CPMI (2018); BIS, SIX and SNB (2020)).

An intraday wCBDC that is used only as a means of payment has fewer implications for monetary policy implementation. Still, Jura highlights two considerations. First, increased use of wCBDC for cross-border settlement may result in higher and possibly more volatile intraday demand for central bank money.[12] Second, access to intraday wCBDC for non-resident banks could increase demand for the overnight reserves held by resident banks acting as correspondents. All this may affect liquidity management for market participants, the price for liquidity and – as a consequence – the efficacy of monetary policy implementation.

An overnight wCBDC also acting as a store of value could lead to money market fragmentation and undermine the singleness of the currency. "Policy equivalence" of wCBDC vis-à-vis central bank reserves would mitigate this risk. This could, for example, require remuneration of wCBDC and adjustments to monetary policy operations (CPMI-MC (2018)).

Access policy

Central bank money settlement is encouraged or required for systemically important payment and settlement systems (CPMI-IOSCO (2012), CPSS (2003)). Besides cash, however, central bank money is currently available only via settlement accounts to a limited range of financial entities, mainly banks.

12 Yet, all else equal, issuance or redemption of an intraday wCBDC as in Project Jura leads to a one-to-one reduction or increase of traditional reserve balances, so that the size of a central bank's balance sheet is unaffected.

Across central banks, there are differences in terms of the type of financial institutions allowed to maintain settlement accounts. Some central banks have broader access policies than others. For example, many central banks permit account access to regulated non-bank financial institutions such as clearing houses, securities firms or insurance companies. Recently, a few central banks have also started to give access to non-bank payment service providers (eg Bank of England (2018)) and regulated fintech companies (eg Swiss National Bank (2019)).

For most central banks, account access is normally restricted to resident banks and other regulated resident financial institutions.[13] The lack of access for non-resident banks reflects several aspects. One example is that a central bank may be unable to rely on the assistance of supervisory authorities from abroad in terms of limiting counterparty credit risk in the case of a distressed non-resident bank. Another example is that non-resident banks are subject to different laws and regulations, which may be inconsistent with domestic frameworks and harder to assess. Similar considerations apply to access to wCBDC for non-resident banks.

13 One exception is the SNB, which allows remote access to the SIC system for non-resident banks and clearing organisations. Non-resident participants in SIC must, for example, have at least the same standards with respect to prudential supervision, anti-money laundering and telecommunications infrastructure.

5 CONCLUSION

Project Jura successfully demonstrates a new way to settle tokenised financial instruments and foreign exchange transactions across borders. It combines the advantages of DLT and a single platform for multiple assets and jurisdictions, while retaining critical controls for central banks, and demonstrates a new way to deploy wCBDC. The DvP and PvP exchanges in Project Jura were conducted instantaneously and atomically, demonstrating that it is feasible to integrate transactions in wCBDCs and tokenised assets on a single third-party platform.

The solution design outlines a flexible approach to allocate control functions across different jurisdictions. This might pave the way for the broader and direct use of central bank money for cross-border financial transactions, contributing to safer and more efficient cross border settlements and therefore to financial stability. The close integration of assets and money on a single platform to which non-resident institutions have access could help unlock efficiency gains. It might also offer scope to improve the efficiency of asset servicing and foreign exchange settlement.

The experiment demonstrated two approaches to interoperability between DLT networks. The dual-notary signing capability allows tokens to be exchanged atomically while residing on different subnetworks. The freezing and mirroring of the NEU CP enables tokens to migrate to a different platform, akin to the principles of a depositary receipt.

The near-real setting of Project Jura facilitated a better understanding of the actual conditions and needed adjustments for a production environment. It required participants to conduct in-depth analyses of regulatory, governance and operational aspects. Back-office staff were directly involved, providing new perspectives. This helped clarify the benefits and hurdles for the use of wCBDC. The near-real setting was also a challenge as it meant that significant legal and regulatory preparations were needed for the experiment to take place, including rulebooks, contingency procedures and monitoring capabilities. As finality for payments was only possible in the RTGS systems, correspondent banks were still required, introducing additional complexity.

Moving to a production setting would require further work. This may include: (i) if, where and how a central bank might delegate functions and activities to a platform operator; (ii) how oversight arrangements could be formed internationally for multi-currency and multi-jurisdiction systems; (iii) integration between DLT platforms and existing payment and core banking systems to achieve straight through processing;[14] and (iv) legal changes related to the issuance of wCBDC to achieve settlement finality on the third-party platform, which would simplify PvP and DvP settlement considerably for a production setting.

Any wCBDC issuance could have an impact on monetary policy implementation that a central bank would need to consider carefully. wCBDCs could be incorporated into novel settlement arrangements that could change the structure and functioning of capital markets, money markets and foreign exchange markets. Broadening the use of central bank money through wider access or increased cross-border settlement could catalyse these changes, as could deeper integration of currencies with other digital assets and securities.

14 The automated interface between the SDX test platform and banking systems was deactivated to comply with the settlement in the RTGS systems and DAR.

In the future, multiple settlement platforms could emerge, with multiple assets and currencies.[15] Central banks would want to ensure that equitable access to central bank money is maintained, guided by objective criteria. Central banks could issue wCBDC on several DLT platforms. This could induce liquidity fragmentation unless it is feasible to seamlessly transfer funds across systems or platforms. Complex governance and oversight issues are also likely to arise. Another option is to issue wCBDC on a dedicated settlement platform that interoperates with other settlement platforms. This could strengthen the degree of central bank control at the cost of increased complexity from the interoperability between platforms.

Project Jura shows how collaboration between central banks and the private sector can shed light on the potential of tokenisation and DLT for cross-border payments and settlements. Future work could explore different design choices and their implications for the related policy questions and the broader emerging tokenised ecosystem (markets, instruments, platforms and participants). While the experiment demonstrates the technical feasibility, the decision will remain with individual central banks as to whether and how they will further explore the issuance of wCBDC.

15 The complexity of the ecosystem could increase further when considering the trading layer, as new trading platforms might emerge alongside conventional trading platforms.

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ANNEX

A DUAL-NOTARY SIGNING FUNCTION

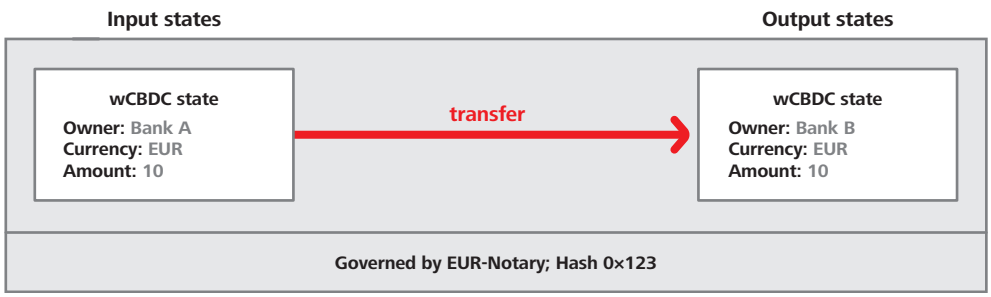
In today's financial market infrastructures, assets are generally maintained, registered or controlled in more than one IT system and accompanying network. Currencies are likely to be controlled by sovereign entities with sole jurisdiction over the use of their respective currency.

To offer a solution that maintains control for central banks over their wCBDCs, but which provides the functionality required for a cross-border exchange, R3 developed a dual-notary signing solution using the Corda platform. The dual-notary signing capability allows to bridge the gap between sovereign digital asset notaries, as seen in Project Jura. This enables assets governed in two sovereign (sub)networks to be swapped without requiring the issuers to trust each other, or to give up control over their assets.

The technique is similar to "hash time locked contracts", opening up cross-chain swap functionality to non-Corda networks in the future. A workflow for an atomic EUR-CHF PvP transaction is shown below to explain how this process allows for risk-free peer-to-peer exchange of value.

In the scenario, Bank A wants to exchange 10 euros for 11 Swiss francs held by Bank B. In Step 1 Bank A creates a transaction which sends 10 euros over to Bank B, as depicted in Figure A1. As Bank A does not apply its required signature to the transaction, the object is effectively a transaction proposal. As such it cannot update the ledger yet, but it can be referenced by its unique hash. The electronic signature of Bank A will be applied later to make it a valid transaction. The transaction proposal is shared with Bank B.

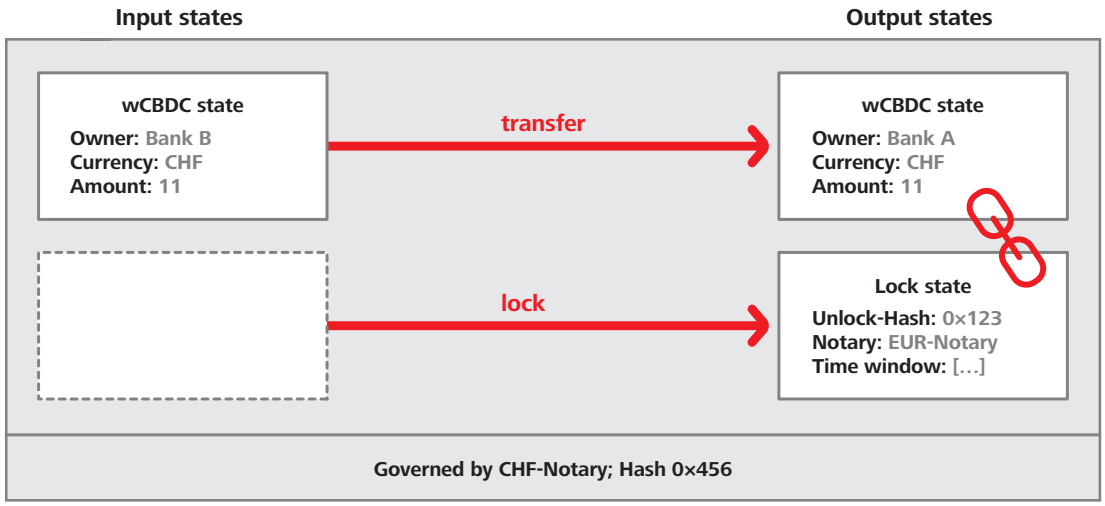
FIGURE A1 – An unsigned transaction proposal by Bank A to send EUR 10 to Bank B



Source: R3.

In the next step, Bank B inspects the received transaction proposal to validate that – once signed – it will provide Bank B with the agreed 10 euros. When this is confirmed, Bank B creates a second transaction, which sends 11 Swiss francs to Bank A, as depicted in Figure A2. All necessary signatures are in place to make this second transaction a valid ledger update.

FIGURE A2 – A specially crafted transaction by Bank B to send 11 Swiss francs to Bank A



Source: R3.

It is important to note that the transfer of 11 Swiss francs to Bank A in the second transaction is conditional. The state proving asset ownership is encumbered on a specially crafted lock state that forces additional controls. The money received by Bank A can therefore not be spent without removing the lock first. This means that, in the case of the dual-notary signing implementation, the lock of the second transaction is removed only when the first transaction is fully signed and executable. The link between both transactions is made via the transaction hash of the first transaction, which does not change.

Bank A, now seeing the conditional second transfer from Bank B, signs and notarises the initial transaction. As a result, the first transaction updates the ledger, making Bank B the unconditional new owner of 10 euros. At the same time, the signed transaction is the key to unlocking the 11 Swiss francs, which therefore become freely available to Bank A.

To summarise, the dual-notary signing function removes settlement risk in a PvP or DvP settlement for financial instruments controlled by separate entities without introducing a third party. To keep the description clear and concise, only the "happy path" with all parties in agreement is explained above. If any party to the EUR-CHF settlement is unsatisfied or unresponsive during the process, the settlement is not processed. This is achieved in above example by Bank A or B not signing their transactions or, at a later stage, by Bank B reclaiming its funds when Bank A decided not to unlock them after a given time window.

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