High School
« ICHEC – ECAM – ISFSC »

Higher education of the long type at university level

Considerations regarding the deployment of central bank digital currencies for retail and wholesale payment markets

Thesis presented by:
Christophe Segers

To obtain the graduation of:
Master in commercial sciences
Academic year of 2021-2022

Promoter:
Aminata Sissoko

Boulevard Brand Whitlock 6 - 1150 Bruxelles

Executive summary

Cash use is quickly declining around the world, implying that central bank money is becoming less relevant. Private providers of digital payment means are gaining ground. Furthermore, the rapid growth of cryptocurrencies and the fact that private big data companies such as Facebook started thinking about issuing their private currencies triggered central banks to provide regalian responses.

In this paper, I will study the considerations regarding the deployment of central bank digital currencies in the retail and wholesale payment markets, and compare the cases of emerging market economies (EMEs) and advanced economies. To better illustrate their concrete differences, I will compare the situation faced by Ghana, The EU, and Sweden.

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I also want to express my gratitude to my parents for their support and Paul Rillaerts for reviewing my paper.

Anti-plagiarism commitment

I, the undersigned, Segers, Christophe, in Master 1 of commercial sciences, hereby declare that the attached work is free of any plagiarism and complies in all respects with the study regulations on borrowing, citing, and exploiting various sources signed when I registered at ICHEC, as well as the instructions concerning referencing in the text complying with the APA standard, the bibliography complying with the APA standard, etc. were made available to me on Moodle. By my signature, I certify on my honor that I have read the aforementioned documents and that the work presented is original and free of any borrowing from a third party not properly cited.

In the context of this online submission, the signature consists of the introduction of the submission via the ICHEC-Student platform.

Christophe Segers, August 2022

Table of contents

List of figures and tables

1 Part I: Theoretical framework

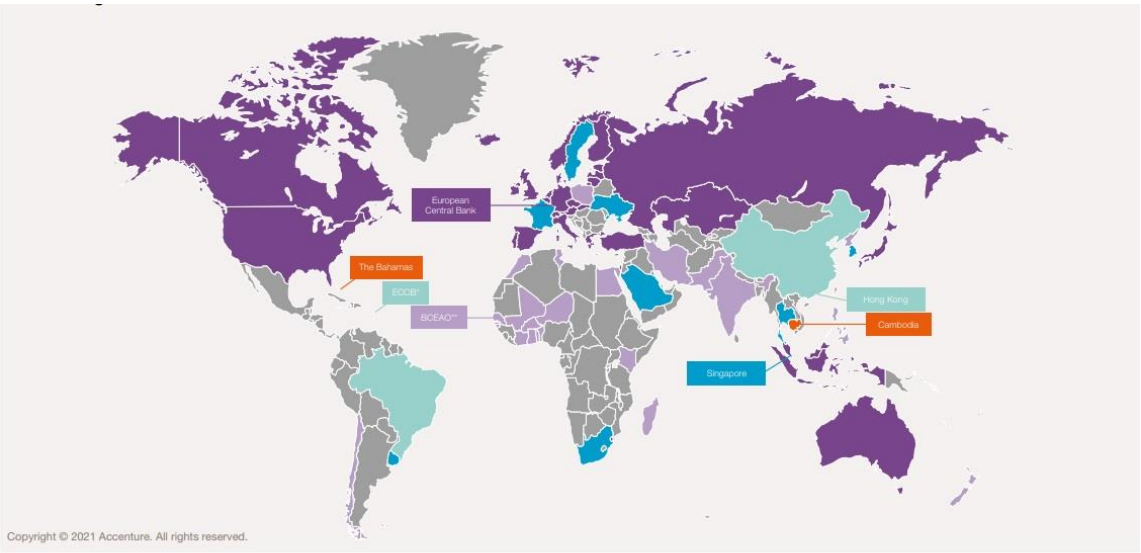
1.1 General Introduction

The way money is exchanged among markets has undergone deep changes in the last decades.

In 2008, the subprime crisis led to a global recession. This event motivated Satoshi Nakamoto -whose identity remains unknown- to create the first blockchain, based on the distributed ledger technology (DLT): Bitcoin, a peer-to-peer ledger allowing its users to exchange money internationally with low fees and delay. According to the authors of Bitcoin's white paper, a solution had to be found back then in order to "allow online payments to be sent directly from one party to another without going through a financial institution"(Nakamoto, 2009).

It's the first time in modern history that a widespread currency isn't issued by a central authority – a central bank-. Moreover, since then a lot of other decentralized DLTs, as well as private big tech initiatives, came into play. When Facebook alluded to the possibility of launching Libra -then renamed Diem-, it felt like a kick in the anthill for central bankers. From 2014 and on, most central banks across the globe started to state their will to investigate the topic. According to a report from the BIS (BIS, 2022), 90% of them, accounting for 90% of world GDP are now interested in CBDCs.

FIGURE 1: THE INVOLVEMENT OF CENTRAL BANKS IN CBDC PROJECTS IN 2021



32	Interest	Countries declaring interest and doing initial internal research to explore CBDC feasibility.
35	Research	Countries that published CBDC research reports and/or conducted early PoCs.
19	Experimentation	Countries that started experimenting and piloting CBDC with limited number of parties.
2	Implementation	Countries preparing their CBDC for a full-scale launch.
2	Launched	Countries that officially launched a CBDC.

Source: SWIFT, 2021, P.6

The increasing amount of money flowing into crypto assets[1], added to the Facebook announcement in 2019 to launch Libra, a private stable coin that could be exchanged worldwide across the famous platform, triggered the interest of central banks to maintain their monetary policy tool channels. Financial regulators couldn't ignore the crypto phenomenon anymore. The progressive decline in the use of cash in advanced economies, which can be attributed on the one hand to the global improvement of digital payments, and on the other to the COVID 19 crisis, exacerbated central banks' willingness to explore innovative ways to remain relevant in the digital era.

Nowadays international or domestic, and public or private financial institutions, such as central banks, commercial banks, SWIFT, the World Bank, the IMF, (international) central securities depositories ((I)CSDs), Accenture, Deloitte or McKinsey, to name a few, are all exploring the CBDC topic, from a retail or wholesale perspective, sometimes both. This topic raises a lot of questions, which we'll investigate in this paper.

In this paper, we will establish the ins and outs of this brand new coming change in the way money is created and used, after having briefly recapitulated the economic concepts and DLT's main properties, which are necessary to understand further developments.

We will figure out what are the drivers for CBDC research for advanced economies and EMEs, and try to answer to a chunk of questions: how can central banks avoid banking disintermediation regarding CBDCs issuance? What new business models could emerge thanks to their programmability? What is their value proposition? Are privacy and anonymity relics of the old world? How do cross-border transfers work, and how could CBDCs help to address the challenges to overcome in these areas? Are cryptocurrencies future-proof with the advent of CBDCs?

1.2 Methodology

I have been very interested in new technologies for a quite long time. In 2017, I was supposed to go to an Erasmus in the last quarter of my third bachelor year at the EPHEC business school -in law-, which would have allowed me not to present a final paper. Due to administrative issues, it wasn't possible for me to experience the Erasmus as intended. Therefore, I was the very last student to pick up a final paper subject. In the list of topics proposed to me, a particular one attracted my attention: "Blockchain and the legal world: what changes are ahead?". Back then, I hadn't even heard about the blockchain concept, nor about crypto-currencies.

[1] According to Coin Shares, inflows into crypto funds and products hit a record 4.5 Billion dollars in the first quarter of 2021. Retrieved from https://www.reuters.com/business/cryptocurrency-inflows-hit-all-time-high-45-bln-q1-coinshares-2021-04-06/, November 2021

The more I investigated this topic, the more I wanted to understand this complex and nascent technology. Looking backward, I am very grateful that my Erasmus got canceled: I would probably have never dived into these deep waters otherwise. At this point I was already sure that, after my studies, I wanted to work in the blockchain industry.

When I started my gateway to an ICHEC master, it was clear for me that I would write my thesis on a blockchain-related topic, but I didn't know which one, as there are thousands of use cases to pick up. NFTs, DEFI, the supply chain were all subjects I wanted to explore, and, thanks to the actualities, and my crypto-enthusiasm, I wanted to know what impact could CBDCs have on crypto-currencies' attractiveness.

It was then a fully new challenge brought to me, because the situation was exactly the same than in 2017: I didn't have a clue of what CBDCs exactly were or what their value propositions was. So, I started my journey by buying "The future of money", a book written in 2021 from a famous Stanford economics professor: Eswar S. Prasad. This book provided a clear picture of how financial technologies could disrupt and reshape the financial ecosystems. Despite being close to graduate in commercial sciences, it's in this book that I heard first about the distinction between retail and wholesale payments.

I started to understand the issues at stake, and wanted to explore two themes that sounded particularly interesting to me: the comparison between advanced economies and EMEs in relation with financial technologies, the potentialities for cross-border transfers, and in particular wholesale cross-border transfers.

I knew that a thesis' subject must be circumscribed in its scope from a time and geography perspective. However, the amount of resources available on a particular subject (for example: the digital euro or the e-krona) were very limited, and it wouldn't have been possible to gather the insights of experts capable of answering cross-cutting questions on a too circumscribed topic. To illustrate this issue, hereafter is a list of central banks' dedicated teams to CBDCs. It is worth noting that this list sums up the CBDC workforce in some of the central banks that are currently the most advanced in CBDC developments.

TABLE 1: NUMBER OF CENTRAL BANK STAFF DEDICATED TO CBDCS AS OF 2022

Central Bank	Number of Staff
CBOB, Sand Dollar	15
BOC	50
PBOC, e-CNY	300
ECCB, DCash	12
Riksbank, e-krona	20
BCDU, ePeso	0 (10 during pilot)

Source: Central banks.
Note: This table does not include private sector personnel. Further, it does not distinguish between those working full time or part time on the CBDC project. The reason is the difficulty in comparing the time spent by part-time employees who, in some phases of the project, may work more than full time. Part-time employed, therefore, often means that they have other tasks besides CBDC. BCDU = Banco Central de Uruguay; BOC = Bank of Canada; CBDC = central bank digital currency; CBOB = Central Bank of Bahamas; ECCB = Eastern Caribbean Central Bank; PBOC = People's Bank of China.

Source: IMF, 2022, P. 26

To balance this statement, however, the table 1 hereabove doesn't count the potential private outsourced staff working with central banks on CBDCs. It is highly likely that the private sector is better supplied in digital technology experts and in CBDC workforce than central banks.

Nevertheless, I took the risk to work on a very nascent, prospecting and evolving topic, because I was deeply convinced that, if I managed to become DLT and CBDC-literate, I could position myself in the labour market of a promising emerging sector.

To dive further in the understanding of the topic, I went through numerous reports released by financial institutions and corporate companies as well as articles written by researchers and university professors. Then I tried to contact the writers of these reports and articles in order to make the most of these materials and to bring my contribution to the research field.

I also thought about performing a quantitative analysis over consumer preferences related to CBDCs, but as such analysis have already been done[2]in far more relevant ways that I would have managed to achieve, as in my surroundings, almost no one has ever heard of the CBDC topic, I chose to bring a qualitative contribution rather than a quantitative one.

The qualitative approach I followed was to gather the insights of central banks' high level task forces staff, (interviews 3, 4, 10), private sector digital experts (interviews 5, 6, 8, 9, 13), economy/ IT professors (interviews 1, 2, 8), experts from international banking institutions (interviews 7, 11, 12, 13) and personnel directly involved in CBDCs' deployment (interviews 3, 4, 5, 6, 7, 8, 10, 11, 13) or fintech in general (interviews 1, 2, 12). I asked specific questions to each respondent, depending on their expertise, the reports or articles they contributed to

[2] See 2.3: Consumers preferences related to the design of CBDCs

publish, and on the technical areas I struggled to integrate at the time of conducting the interviews.

These interviews helped me to understand both technical considerations regarding DLTs, payment ecosystems functioning, and how the current situation could concretely change -or not- with the advent of CBDCs. I sum up the insights they gave me in part IV of this thesis.

I based the structure of this paper on my understanding of the issues at stake, with the help of my promoter Dr. Aminata Sissoko and thanks to the inputs of the respondents.

1.3 Research question and structure of the paper

The aim of this paper is to understand the considerations related to CBDC deployment for retail and wholesale payments markets. This is a broad topic, and I will compare retail payments markets between advanced and developing economies and study implications related to wholesale cross-border CBDCs. With this objective in mind, I will structure this paper as following:

A first theoretical part where I present the concepts necessary to understand how the current situation is likely to change -or not- with the advent of retail and wholesale CBDCs.

A second part which will focus on retail CBDCs: the motivations for regulators to issue them, the risks at stake and how regulators may mitigate them, the consumers' preferences when it comes to retail CBDCs' design, and then compare the implications between advanced economies and EMEs. To illustrate this comparison I will differentiate between the digital euro, the Swedish e-krona and the Ghanaian e-Cedi.

In the third part, I will investigate the wholesale CBDC (wCBDC) potentialities for cross-border transfers. I will focus on cross-border transfers as such, through the correspondent banking system, but also on foreign exchange (FX) transactions and securities settlements, which are some of the most exciting use cases regarding CBDCs. Among the few projects that already have been tested, I will present the project Jura and the experiments conducted by SWIFT, and summarize the lessons that can be taken from them.

The last part will be dedicated to my contribution to the research through the interviews I gathered, the limits of my work and eventually the conclusion of my research and avenues to explore to go further.

1.4 Global perspective

In the last decade, 3 macro phenomena are to be taken into account to depict changes in the way money is exchanged among financial markets.

First the declining use of cash. According to Cecilia Skingsley, the First Deputy Governor of the Riksbank[3],"If we extrapolate current trends, the last notes will have been handed back to the Risksbank by 2030"[4]. In Europa, especially Sweden and Norway are experiencing this trend.

Several factors can explain the progressive worldwide decline in cash use. In 2019, a paper released through the IMF (IMF, 2019) highlighted the role played by demographic change among 11 countries in the decline in central bank money use between 2006-2016. Younger people favor cash substitutes such as credit cards or mobile payments, while the elders still rely heavily on cash. In these 11 countries, the average composition of the population changed by 2% a year: on average, the birth rate was 1,2% whereas the death rate was 0,8%. The average cash share across the studied countries fell by 1.3 to 2.2 percentage points. Another study conducted in 2022 (Humphrey, 2022), which covered 25 countries, came to the conclusion that all but one (Turkey) of the countries studied are experiencing a decline in cash use.

The degree of reliance on cash and the extent to which cash substitutes are present in a given country may drive the demand for CBDCs when issued. In many OECD countries, bank cards and mobile payments are ubiquitous. The fact that CBDC is just as convenient as, but not better than physical money, is a definite advantage in a country where bank cards and e-money are rare or have not yet been introduced on a large scale (IMF, 2019).

The Covid 19 pandemic amplified the shift in payment behaviours: a report published by McKinsey (McKinsey, 2021) highlighted that cash payments had globally declined by 16% in 2020.

Second, financial engineering and fintechs[5] have known deep advances in the way financial products can be exchanged and sold among corporations, private banks and households. The design of new financial instruments and products allowed these actors to trade loans, for example, as distinguished securities, splitting their components: principal in one side, interest payments to another.

This was expected to mitigate the risk incurred by borrowers while increasing the possibility for banks to provide loans by lowering eligibility requirements. But it turned out it didn't happen like that.

[3] The Riksbank is the Swedish central bank, created in 1668. It's the first bank in the world to have issued banknotes (Prasad, 2021)

[4] Recuperated from https://my-life.lu/en/is-the-end-nigh-for-physical-money-30054/

[5] Contraction of finance and technology, used to design the technological actors disrupting the banking and financial sectors

More exotic financial products and lighter regulations actually exacerbated the fragilities of the financial system until the breaking point in 2008 with the subprime crisis.

Greediness for short term profits and larger bonuses induced by the possibility of taking more risks led to single points of failures in the strongest financial institutions back then, such as Lehman Brothers, previously seen as paragons of stability. The entanglement of banks, coupled with massive cash inflows from poor economies to the richest[6] then led to the 2008 crisis as we all know.

This situation prompted new regulatory requirements – Bale III- to be adopted in order to strengthen the control and risk management of international banks.

Thanks to these regulatory reinforcements, financial institutions were better prepared to withstand the COVID 19 shock pressure.

Third, parallel to this progressive cash disappearance and financial engineering progress, the emergence of the DLT in 2009 reshaped the financial possibilities by bringing financial innovation to the upper level.

The first use case DLT proposed through Bitcoin was the possibility to exchange value between persons or entities unknown to each other, without the need to require external stakeholders such as banks, notaries or financial clearing houses.

All around the globe, central banks took a dim view of the advent of such a possibility. Since 2009, most of them continuously bashed crypto-currencies (but not the technology behind), affirming that these currencies were, for most of them, pointless, dangerous to invest in, extremely volatile and that they could facilitate money laundering or terrorism financing.

For instance, since 2013, Chinese financial institutions publicly banned Bitcoin, Bitcoin mining, the crypto-sphere and crypto-related products several times[7].

While banning decentralized issued money, Chinese institutions were working on building a paperless and much more centralized digital currency.

In fact, the Chinese renminbi and the Swedish krona are maybe the most prone paper currencies to become relics (Prasad, 2021). Countries over the world are moving at different speeds and from different starting points when it comes to the decreasing use of cash, but most of them are moving towards the same direction.

In the meantime, the majority of central banks around the globe started to inform about the CBDCs potentialities in order to maintain the public access to risk-free central bank money. According to a survey from the BIS in 2021, 86% of them are actively prospecting, 60% are experimenting and 14% are already deploying pilot projects (*BIS*, 2021)[8]. The first major

[6] For instance, the US trade deficit owned by China has skyrocketed from 6 million $ in 1985 to 268 billion in 2008 : available at https://www.census.gov/foreign-trade/balance/c5700.html#1991, See appendix 2 for pictorial details. November 2021

[7] Retrieved from https://www.coindesk.com/learn/china-crypto-bans-a-complete-history/, November 2021

[8] Retrieved from https://www.bis.org/about/bisih/topics/cbdc.htm, November 2021

economy to fully implement this kind of national currency should be China. According to Björn Segendorff (interviewee n°1), if Sweden is to launch a definitive CBDC (which is not sure at the moment this paper is being written: the Swedish parliament will have to deliver its thoughts on November 2022), it will take at least five years from the moment of delivery of the mandate by the Swedish parliament.

But next to major economies, different countries have already given a try to CBDC: the Bahamas deployed its sand dollar in October 2020, Nigeria its eNaira in October 2021, Jamaica its Jamaica Digital Exchange in June 2022, to name a few. But the biggest economy of the world about to implement such a monetary change of paradigm would definitively be a milestone in the global digital transition.

Last but not least, cross-border transfers still have room for improvement. These transfers are particularly slow, opaque, risky and costly to process as they involve many intermediaries from different jurisdictions. In 2020, the G20 released a roadmap to reduce or eliminate the friction inherent to such transfers. WCBDCs are the most exploratory topic of this roadmap. We will focus on this topic in the third part of this paper, as it involves wholesale money instead of retail money.

FIGURE 2: ENHANCING CROSS-BORDER PAYMENTS: BUILDING BLOCKS OF A GLOBAL ROADMAP

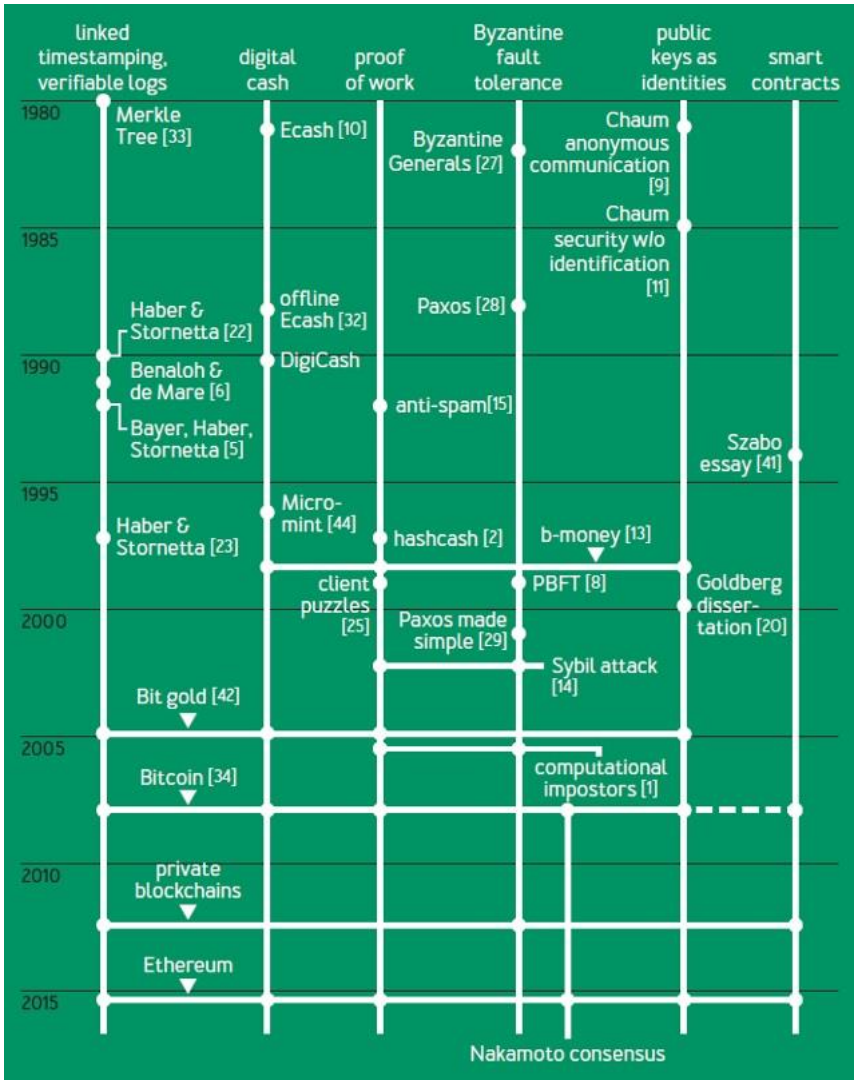
Source: CPMI, 2020, P.5

1.5 DLT features

The DLT is born with Bitcoin, in 2009. This technology is pretty vast and complex to explore, as thousands of different blockchains and protocols have emerged since Bitcoin. I won't present all the nuances and the forms it can take, but rather list the fundamentals that can help us understand how this technology can be useful for financial actors and regulators. At this point, the reader must just understand that DLT are about distributed ledgers, as opposed to centralized ledgers.

Here is a summary of the different legacy technologies that allowed the concept of blockchain to emerge, presented in a timeline.

FIGURE 3: CHRONOLOGY OF CONCEPTS INVOLVED IN BLOCKCHAIN DEVELOPMENTS



Source: Narayanan et al., 2017, P.2

To understand this technology, it is worth remembering some of its first inherent features: distribution, immutability, transparency and anonymity (Ghiro et al., 2021). I added programmability to the list because, even if it wasn't included in the first DLT, it is essential to understand CBDC potentialities. Conversely, I didn't mention decentralization but rather distribution, because CBDCs won't be decentralized but are likely to be operated through distributed infrastructures. I will also present the token properties of DLTs which are crucial to understand how CBDCs could streamline the settlement processes, particularly in cross-border transfers.

Nakamoto actually never uses the term "DLT" in its white paper, but instead describes how transactions, cryptographic hashes, and nonces can be grouped together into a block-based data structure in which each block is chained with one another by the inclusion of the hash of the previous block. DLTs are today are not necessarily operating a chain-like structure. They mostly understood as trustless systems.

Key characteristics of DLTs, mentioned hereafter, don't apply equally to the different types of existing blockchains. They should be perceived as a continuum variable, fluctuating depending on the type of blockchain we are interested in. In the cases of CBDCs, DLT-based solutions are almost always explored[9], but not necessarily in a blockchain. This is why we will focus on DLT rather than on blockchain. Hereafter are the characteristics of DLTs I found necessary to understand prior to diving further into the CBDC topic.

Distribution

"DLT refers to a novel and fast-evolving approach to recording and sharing data across multiple data stores (or ledgers). This technology allows for transactions and data to be recorded, shared, and synchronized across a distributed network of different network participants". (World Bank, 2017, P. 7)

In cross border transfers, this distributed nature of the technology makes instant settlement possible by providing monitoring, controlling and notarizing capabilities to the permissioned nodes.[10]

Immutability

Immutability is often perceived as one of the most important DLT's feature, "since it allows for the transformation of the "Internet of Information," in which digital data can be copied without loss of accuracy, into the "Internet of Value," in which units representing value can be transferred between peers and double spending can be prevented" (Treiblmaier, 2019, P.3).

[9] With the notable exception of China, where more centralized technologies are being investigated
[10] See 3.3.5 for a concrete example

DLT's features also depend on the type of use case participants are willing to address: immutability is highly desirable in a situation where traceability is needed, but if we take the example of the way personal data are handled in Europe, the GDPR (Art. 17) requires that organizations must provide individuals with the possibility to erase some personal data, if they match a few criteria[11]. CBDCs will have to be compliant with data protection regulations (see interview 13).

Transparency

"The transparency of DLTs is achieved by allowing users read-only access to previous transactions and to inspect the content of transactions and smart contracts" (Kshetri, 2018).

Again, it is essential to distinguish between private or permissioned DLTs and public or permissionless DLTs, the first being run by members of a consortium operating private nodes, when the second allows for the inspection of blocks by any user.

Even if transparency is desirable in many cases, this doesn't prove true to all use cases. For instance, as stated hereabove, individuals may be concerned about sensitive data being accessible, and some entities might fear confidential financial information leaks. If we think about tokens containing information about all the previous information it went through, it might prove an issue when dealing with countries having less stringent data protection rules enforced. If a given CBDC is to be transferred to foreign jurisdictions' FMIs under less stringent user protection rules than the GDPR, the integrity of the European consumers' data could be at risk. This is why prior harmonization in data handling rules is needed before safe interoperability implemented between CBDC infrastructures and legacy RTGS systems (which I'll present here after), but we will come back on this matter in the part III of this thesis.

Moreover, participation in public DLTs is pseudonymous and not anonymous, which raises privacy issues as it does not prevent identification (Meiklejohn et al., 2016).

Anonymity

As mentioned here above, DLTs can offer anonymity, or at least pseudonymity to their users. However, this is a feature that can be balanced by the designers of the DLT. When talking about CBDCs, it is highly unlikely that regulators will implement a fully anonymous DLT, as financial institutions need to comply with data protection, AML, KYC and CFT rules. We will see later in this paper that compromises can be made by establishing thresholds beyond which no anonymity will be granted to the transactors.

[11] Recuperated from https://gdpr.eu/right-to-be-forgotten/#:~:text=Also%20known%20as%20the%20right,to%20delete%20their%20personal%20data.&text=The%20General%20Data%20Protection%20Regulation,collected%2C%20processed%2C%20and%20erased,

Programmability

This feature has been brought to the DLT table in 2014 by Ethereum, the second most known public blockchain, on the basis of a concept developed by Nick Szabo (Szabo, 1997). Through smart contracts, IE computer protocols that facilitate, verify and execute the negotiation or execution of a contract, it is possible to automate transactions, to program payments depending on the occurrence of a particular event, to settle atomic transactions or to program the token itself to limit its functionalities.

This innovation allows to bypass the need for an intermediary and shifts trust in third parties to trust in programming languages where transactions are settled based on the data harvested by an oracle in charge of acting depending on realizations of conditions established in the code. According to Dr. Ousmène Jacques Mandeng (interview 8), these features are particularly interesting for financial institutions when exploring the CBDC topic, but are less likely to be implemented in the early stages of a CBDC implementation because financial regulators would want the infrastructure to remain unencumbered. Yet, implementing programmable features into a CBDC is a new and exciting debate in the financial sector, which we will explore to some extent.

According to Bernard Nicolay (see interview 1), programmability and smart contracts are not necessarily implying DLTs. However, this topic has been brought to the table by DLTs and I chose not to investigate further in smart contracts literature involving other technologies than DLT because I didn't think it was useful to understand this thesis.

Token properties

DLTs imply tokens, which can be understood as digital representations of values. The difference between such tokens and the digital representation of value in traditional banking systems is that the token acts like cash in the tangible world: exchanging tokens implies settlement, such as exchanging banknotes. This technology can have huge impacts on the efficiency of payment systems by eliminating the need to pass by numerous intermediaries. Moreover, a comprehensive history of transactions lies in the token itself, which means that it is possible to know exactly what transactions he went through. Conversely, units in traditional bank accounts are not traceable up to their issuance.

TABLE 2: BENEFITS OF TOKENIZATION IN THE REAL ESTATE INDUSTRY

Advantages	Definition
Liquidity	The transformation of illiquid real estate investments into "tokens" means that a direct investment in a property is vested with the character of an indirect investment. Issuers can, as a result, secure a higher liquidity.
Fractional ownership	Tokenization allows a broader group of investors to invest directly in real estate.
Lower transaction costs	"Tokens" enable transactions, that are more cost effective. An increase in efficiency regarding the transaction execution is observable due to a faster processing.
Transparency	Transparency is the central feature of the blockchain technology and contributes to the increase in attractiveness of tokenization as an investment opportunity. After completing a transaction on the blockchain, it can no longer be changed and can be verified through the network. Thus, the completed transaction can neither be manipulated nor canceled.
Automation	Through so-called "smart contracts", numerous intermediate steps, such as compliance, document verification, trading, opening an escrow account but also dividend payments, can be carried out automatically via the blockchain.

Source: De La Rubia, C. (2021, January 22). Frankfurter Allgemeine., Grätz, C. (2020, February 27). Banking Hub., Cashlink (2021), Finexity (2021), RICS/Lucerne University Webinar (2021). Tokenization in the Real Estate Industry.

Source: EY, 2022

We will come back on this notion in part III of this thesis.

1.6 Interoperability

Interoperability refers to the possibility for different systems speaking different languages to talk to each other and to exchange information. This concept is deeply investigated in interviews 5, 7, 8, 11, 12, and 13. It can apply to CBDCs built on different platforms, but also to transactions between CBDC-based currencies and legacy currencies[12] which is key to enable cross-border transactions to take place in the early stages of CBDC adoption.

Interoperability is achievable[13], and raises more legal than technical issues. These will be explored throughout this thesis.

1.7 Money

While there is no singular definition of money (economists, central bankers or financial markets participants may all have a different definition in mind), we will focus on its properties:

"Money is a commodity accepted by general consent as a medium of economic exchange"[14]. Two monetary aggregates are useful for evaluating the outcomes of a monetary policy (Prasad, 2021): outside, or central bank money, and inside, or commercial bank money.

[12] See 3.3.4.1: SWIFT first experimentations for a practical example
[13] See 3.3.5: Project Jura

1.7.1 Outside money

Outside money refers to the money issued by the central bank of a given jurisdiction (or any other authority mandated by the government or the central bank). It relates to money created outside the private sector, and is often called fiat money. This type of money has value because, in a given territory where it has the legal tender status, it is not possible to refuse a payment made in such currency. Governments can also require their tax obligations to be paid in such a currency. Central bank money is also perceived as less risky, because it's a liability on the central bank, which is the lender of last resort, and not a liability on a commercial bank, which can collapse.

At the time this paper is being written, outside money consists only of coins and banknotes issued or printed by the central banks, as well as digital reserves held by the registered financial institutions at the central bank and foreign currency reserves, but this situation is likely to change with the advent of CBDCs, where a central bank will have the possibility to directly issue digital currencies. The advent of CBDCs is likely to ease the access to outside money, particularly for non-resident institutions.

As we will see further in this paper, the issuance of such digital currencies could help maintain the relevance of outside -or central bank- money in times where privately issued money is gaining traction.

1.7.2 Inside money

Inside money refers to the money created through entities in the private sector. When a household gets a loan approved by a commercial bank, the latter has created money from scratch: a liability is credited on the borrower's account, while an asset is created on the debit account of the entity's balance sheet.

A key difference between outside and inside money is that inside money is in zero net supply in the private sector: "the assets and liabilities generated by the creation of inside money exactly offset each other, leaving a zero net position on the overall private sector balance sheet" (Prasad, 2021).

On the other hand, outside money is a liability on the central bank's balance sheet, but an asset on the private sector balance sheet. Numbers vary country by country, but on average, inside money accounts for 80% of the money in circulation (SWIFT, Accenture, 2021).

[14]Recuperated from https://www.britannica.com/topic/money, December 2021

1.7.3 Core functions of money

Money serves three functions (Prasad, 2021):

1) A unit of account

Money denominates the price of goods and services, creating a concrete way to express and evaluate the value of the latter. A dominant unit of account lowers the exposure to price risks and volatility (Doepke & Schneider, 2017).

2) Medium of exchange

Money can be exchanged through financial markets to buy goods and services, acting as an intermediary between buyers and sellers.

3) Store of value

This concept refers to the ability for a currency to maintain its purchasing power over time.

CBDCs have potential for impacting these three functions. From a unit of account perspective, implementing a CBDC could imply for a country to offer a more attractive currency, thereby lowering its exposure to volatility and monetary substitution. From a medium of exchange standpoint, CBDCs can ensure the general access to a risk-free mean of payment and could help reducing or eliminating the friction in cross-border transfers.

In the store of value area, according to Johanne Evrard, economist at the ECB (see interview 10), decisions will have to be taken in order to avoid banking disintermediation and financial instability, for example through holding limits or incentives not to hold beyond a certain amount of retail CBDC like the application of negative interest rates. A limitation of the store value function of the CBDC has to be implemented.

These topics cover a wide range of problematics, which will be developed in the following parts of this thesis.

1.8 Considerations regarding retail and wholesale payment systems

In order to understand how retail and wholesale payment systems work, it is worth considering their ecosystems first and what missions they are designed to fulfill.

To be settled, domestic retail and wholesale payments need to pass by several intermediaries which handle the netting and clearing operations prior to the settlement. These are the following:

1) Automated Clearing Houses (ACHs) are charged of netting and clearing the transactions and transfer the cleared amounts to RTGS systems, and (I)CSDs when securities settlements are involved (see interviews 8 and 12).
2) (International) Central Security Depositories ((I)CSDs): These public institutions only intervene in securities settlements[15]. They hold securities and perform Delivery versus Payment (DvP) mechanisms to eliminate the counterparty risk in securities settlements by processing payment and securities exchange only if they are both credited on each account of the transaction. DLTs can offer other ways to get rid of this risk by enabling tokenized securities and tokenized central bank money to be transferred only if their counterpart is set to be transferred.
3) Real Time Gross Settlement (RTGS) systems are managed by central banks to settle the cleared amount of transactions, payment by payment. They only operate during business hours for wholesale payments, which makes final settlement of international wholesale transactions happening at T+2 to T+3 for cross border transfers, that need to pass through different RTGS systems and time zones. This is the main source of friction in international transfers (See interviews 5, 7, 8, 11)

Retail and wholesale cross-border transfers need to pass by such institutions in different countries to settle each leg of the transactions. As institutions between different jurisdictions want to transact between themselves without necessarily having previous arrangements, there is often a need to pass by numerous intermediaries through the correspondent banking system. We will see how in particular the correspondent banking system is sub optimal and how CBDCs could shortcut the existing infrastructure in part III of this thesis[16].

4) To ensure that Financial Market Infrastructures (FMIs) are speaking the same language, SWIFT provides a unified and standardized financial messaging network.

The vast majority of transactions over the world are retail, while the majority of the funds exchanged occurs through much less numerous wholesale transactions of vastly bigger amounts.

[15] See 3.2
[16] See 3.3.1 : Today's situation

The final settlement of both retail and wholesale transfers finally occurs on the RTGS system, payment by payment.[17]

The concrete difference is that the final settlement of retail transactions is arranged by the RTGS system on a DNS[18] basis, meaning that, with appropriate collaterals at disposal and because of the smaller value of the transactions, it usually operates 24/7/365.

From a retail perspective, Commercial banks provide financial intermediation, i.e. the transformation of savings into investment. This feature is particularly important when the economy faces a huge inflation, which implies rising prices eroding the purchasing power.

They also provide consumers with maturity transformation, which implies that banks' liabilities (households' deposits) are very short term while most of their assets (loans) are on a very long term (Prasad, 2021). A well-functioning commercial bank ecosystem is a key component of financial stability. This is why financial regulators are paying attention not to disrupt such an ecosystem.

1.9 CBDC: presentation of the concept

A CBDC is, first of all and regardless of the technology behind, digitalized central bank money. As mentioned before, the vast majority of central banks around the world showed signs of interests in this modern topic. They want to maintain the possibility to channel a money medium which will guarantee that they still have room for maneuver from a monetary policy standpoint. They also want to provide their citizens with a risk-free means of payment. As we will see, advanced economies and EMEs have generally different motivations to build and adopt CBDCs. Each country has actually different motivations, because the challenges they face are never exactly the same, but one of the objectives of this paper is to deduct meaningful trends among advanced economies compared to EMEs.

Compared to today's situation, CBDCs are likely to disrupt or impact two different payment channels. being: retail payments, on which we will focus hereafter in part II of this paper, which encompass payments between consumers, companies, and public authorities[19], and wholesale transfers (both domestically and internationally), which are transfers between financial institutions. We will focus on these in the third part of this paper.

[17] Retrieved from https://digitalpoundfoundation.com/the-retail-versus-wholesale-debate-should-retail-and-wholesale-clearing-and-settlement-of-cbdc-payments-be-separated/, February 2022

[18] DNS systems are systems where the payment obligations can be postponed to be paid later thanks to concluded agreements between the involved parties. Recuperated from https://corporatefinanceinstitute.com/resources/knowledge/finance/net-settlement/, July 2022

[19] Recuperated from https://www.ecb.europa.eu/paym/integration/retail/html/index.en.html, January 2022

1.10 Central Banks mandate

The basic functions of cash, both for the general public and for monetary policy, must be maintained in a world where the use of cash is steadily declining. Therefore, where the central bank already has a mandate to issue cash, it also has both a right and a duty to reinforce tangible cash by issuing a digital equivalent and complement.

Therefore, there is no need to give this mandate by first amending the law. At contrast, under current law, cash is not an instrument of monetary policy. If it were to be used in the future for this purpose (for instance through positive or negative interest rates), a change of law based on a democratic decision made by a fully informed parliament would be necessary.
In this perspective, 'fully informed' means that it must be made clear that a change in the law is mandatory not because of the introduction of new forms of monetary value representation, such as tokens, but rather because the use of cash as a part of the monetary policy toolkit is new and would violate the mandate of price stability and the principle of an open market economy.

Amendments in the law are therefore necessary wherever a retail CBDC is to be equipped with properties and functionalities that tangible cash lacks. (CEPR, 2021)

2 Part II: Retail CBDCs

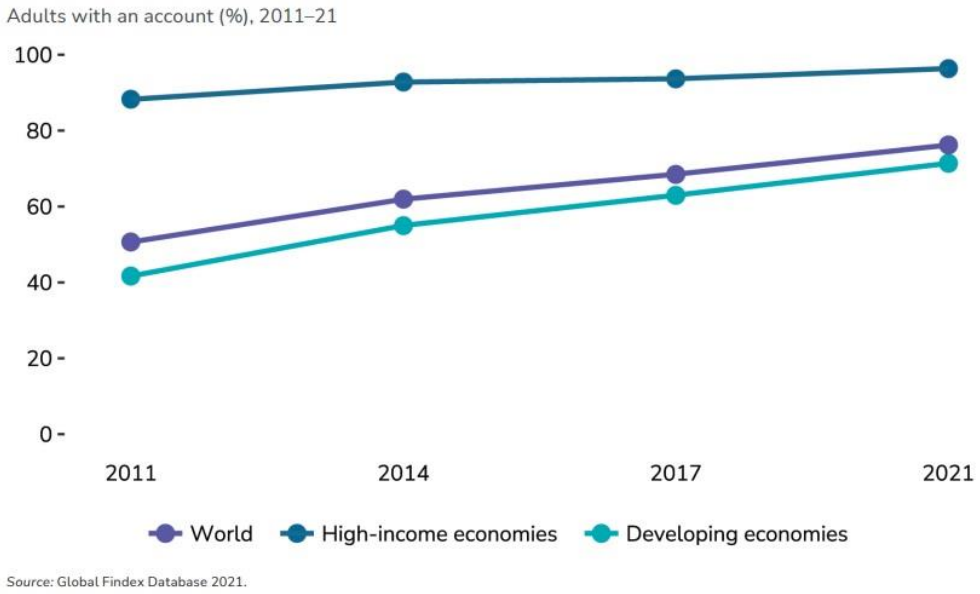
2.1 Motivations to issue retail CBDCs

2.1.1 Financial inclusion

Motivations behind issuance of a retail CBDC vary by countries, jurisdictions and locations. In advanced economies, financial inclusion is already a well-established reality, although a few percent of the population of these countries is still unbanked or underbanked. So, there is room for improvement as even these small percentages account for millions of people. Still, this is not the main motivation behind advanced economies' central banks to issue retail CBDCs.

In EMEs the story is not the same, even if numbers are getting better quickly thanks to digital payments initiatives[20]. According to the World Bank, (World Bank, 2021), from 2017 to 2021, the average rate of account ownership in these countries increased by 8%, from 63 to 71%. See figure 4 here below.

FIGURE 4: FINANCIAL INCLUSION IN ADVANCED ECONOMIES VS EMES



Source: World Bank, 2021, P. 37

EMEs' population also often lack competitiveness in the banking sector, implying that only the most privileged citizens have access to payment services. We will study EMEs and the Ghanaian situation to illustrate which issues CBDCs are designed to solve here. A telling example of a successful digital payment initiative is M-Pesa, a money transfer system put in place by telecom companies in Kenya (see interview 8).

A retail CBDC could help foster the financial penetration and serve as a gateway to basic financial services offered by the private sector.

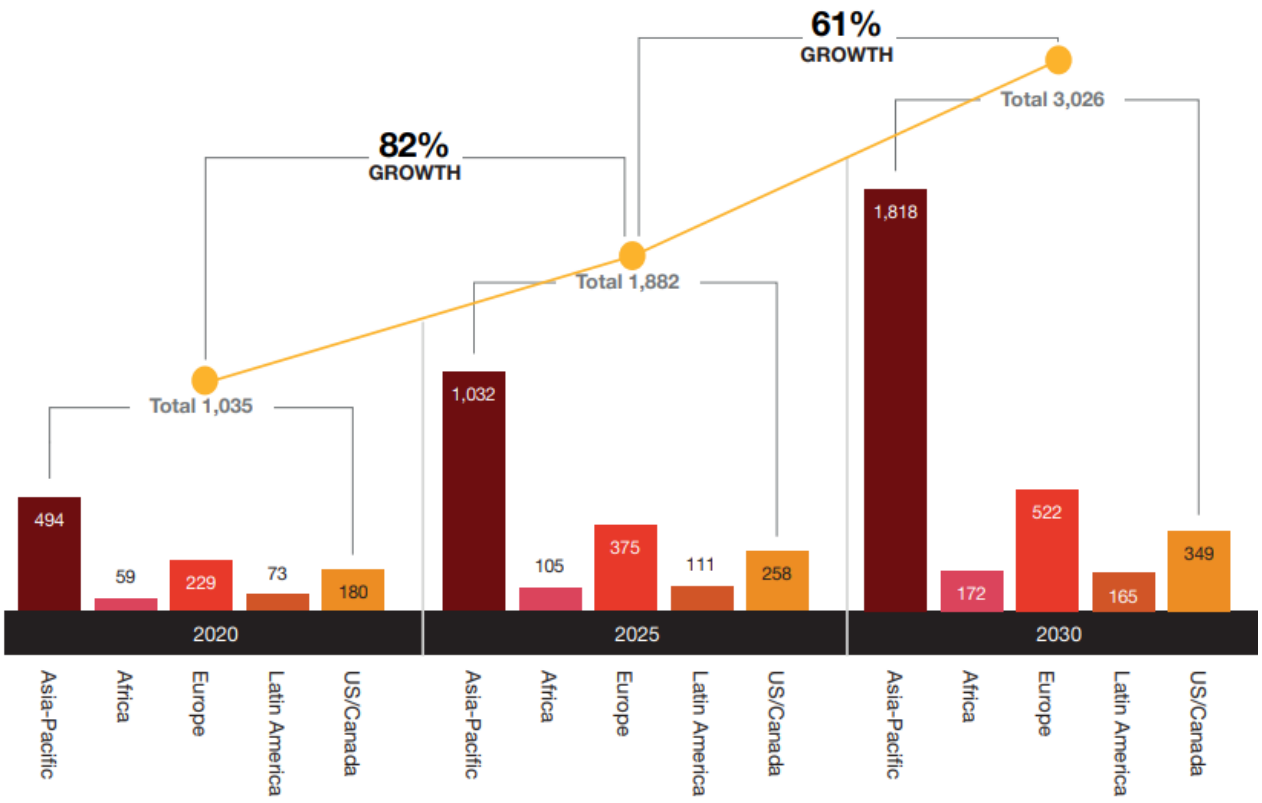
[20] See 2.4.1.2 to understand the input of digital payments in financial inclusion

CBDCs should be more easily accessible than bank accounts, according to Marcello Miccoli (interview 11). Because they are likely to be held on smartphones or smartcards which will be made very available. They will also likely work offline. EMEs' consumers tend to be more enthusiast about CBDCs than in advanced economies[21]. If financial regulators want to foster financial inclusion, they will have to design CBDCs with ease of use and attractive features. In advanced economies, this statement must be balanced to avoid financial disruption and instability by making CBDCs too attractive compared to traditional payment means which are doing their job quite well. More attention must be paid to avoid the disintermediation of a well-functioning ecosystem (see interview 10).

The Covid-19 pandemic, which started in early 2020, has also triggered the shift towards a cashless society thanks to lockdowns preventing shops to open.

According to a paper released by PricewaterhouseCoopers (PwC, 2021), the volume of cashless payments across the world will increase by more than 80% from 2020 to 2025. See figure 5 here below.

FIGURE 5: EVOLUTION OF CASHLESS PAYMENT VOLUMES



Source : PricewaterhouseCoopers, 2021, P.3

[21] See 2.3

2.1.2 Monetary sovereignty

Retail CBDCs have a number of applications. One of them (see interview 5) is to enable a country's jurisdiction to still have sovereign digital payment rail independent of cards, bank and commercial applications where central bank money in a digital format can be a public utility, so it can be used by the population at large to transact day-to-day and to perform their transactions without needing to rely on big tech and finance companies such as Facebook, Amazon, Visa, Mastercard, PayPal, Alipay, Google Pay, etc. (see interviews 1, 2, 3, 4, 6, 10).

The ability to perform digital day-to-day transactions is perceived by central bankers as a public good because of the hypothesis of the advent of a national disaster such as a war or a confidence crisis in one or in some private payments services providers. Retail CBDCs therefore also bear national security implications. Furthermore, as long as private players control the financial flows, they control and monetize the payment data that they collect. Putting in place a digital payment channel would ensure central bankers and governmental authorities can better monitor the state of the economy, thanks to the aggregate flows of payment data (see interviews 3 and 6). The more granular and individual data will still be held by the private payment service provider (PSP) providing the actual CBDC account and consumer interface and complying with the data protection and AML, KYC and CFT rules.

Monetary sovereignty issues can arise from the private sector, as exposed here above, but also from the lack of trust in a country's currency because of weaker economic and institutional fundamentals (see interview 11) resulting foreign countries hegemony in currencies' payment volumes offering more trust than less competitive currencies, for example in EMEs.

Dollarization happens when the US$ partially or totally replaces the domestic currency in a given country.

Attractiveness is key when it comes to money use. Therefore, equipping a currency with new properties may reduce the incentives to use a foreign currency, typically the US$ (see interview 8). However, high volatility and inflation are still issues to solve and CBDCs won't tackle these (see interview 11).

CBDCs could help making national currencies more attractive. The debate of whether or not non-resident institutions should be able to hold national currencies is running among central banks, but this possibility would definitely make national currencies more usable and accessible in international payments, thereby reducing the pressure for dollarization.

Conversely, foreign CBDCs equipped with new functionalities could threaten legacy currencies' competitiveness.

2.1.3 Monitoring the state of the economy

If the CBDCs are to be deployed, it is most likely that central banks won't have access to the granular data of the payments performed by individuals, neither would they have an interest in doing so. By contrast, having access to the aggregates of data could help central banks to better assess the state of the economy at any given time.

In a country where a retail CBDC would be adopted and used widespread, central banks would gain instant vision on in and outflows within the economy. At the moment speaking, if a given central bank wants to have access to the aggregates of payments data, it would have to contact payment service providers such as VISA, but this is again a cumbersome process. Having a direct access to the trends affecting the amount of money in circulation could help central banks to better evaluate and formulate policy measures.

According to Bernard Nicolay (see interview 1), expanding the access to central bank money to non-resident institutions could also widen the impact of policy measures, because the more institutions are connected to the central bank, the more it can have financial impacts.

Retail payments are basically made of cash on the one hand, IE banknotes and coins, and credits cards, mobile pay apps and all sort of digital payments on the other. These are used by households to perform day-to-day transactions. In many countries, there is a threshold beyond which you theoretically can't pay with cash. In Belgium, for instance, this amount is fixed to 3000 euros (see interview 3). The reason behind is to constrain money laundering. Thinking about retail CBDCs, these limits are likely not to change when it comes to the amount it will be possible to pay fully anonymously. A balance must then be found between traceability and privacy.

Increasing digital payments brings transactions into the national financial framework and reduce the size of the shadow economy[22]. It could help enforcing AML, KYC, CFT and bribery issues in economies experiencing a greater proportion of informality.

According to all the experts I had the chance to interview, there will also be a threshold beyond which fiscal authorities will have automatically access to the payments data. The amount of the threshold is a feature that still needs to be figured out. Pauly Baümler (see interview 6), who is business developer at Giesecke+Devrient, which is a technology audit consultancy firm working, among other things, on the Ghanaian eCedi, explained that G+D built a CBDC simulator developed with their partners to assess the impacts and outcomes of different thresholds. So, the question is still being debated and there is no concrete answer to that yet, it will need to be explored by the governmental and fiscal authorities, by jurisdiction.

[22] See Figure 9.B: Informality is lower where digital payments are higher (Feyen et al., 2021)

2.1.4 Enable programmable features

The programmability of CBDCs encompasses two kinds of phenomena: the programmability of payments, and of the currency itself. Programmability of payments could be understood as automation. One of the ways you can set up programmable payments through smart contracts is by having oracles, which are nodes that observe certain facts, conditions, and upon observing those conditions, certain payments might be triggered from one place to the other.

The programmability of the currency itself refers to the possibility of allowing certain types of tokens to be used only for certain purposes. In times of crises or in a zero or low inflation environment, we could think about helicopter drops of money which would be usable only for essential goods for example, within a particular period of time (Prasad, 2021). But this would run counter to the fungibility of the currency. If some tokens are usable everywhere at any time, and some others not, the intrinsic value of the latter shouldn't be the same as the former.

This is the reason why, according to Axel Van Genechten, digital currency expert at the National Bank of Belgium (see interview 3), programmability of money is less likely to occur than programmability of payments, because CBDCs are confusing enough even without bringing currencies of different status on the table. Central banks need the population to trust CBDCs, and early deployed programmable features could hamper trust. They also want CBDCs to be unencumbered, and putting too much programmability too early could make transactions cumbersome to process.

Automating fiscal operations is well illustrating the possibilities allowed by payments programmability features. It's a brand new debate rising among central bankers, deriving from the idea of payments programmability (see interview 8, 10) . For the time being, central banks may be reluctant to put too much programmability into CBDCs, because they want the currency to be unencumbered. However, if CBDCs were to be put in place, the infrastructure could serve a wide range of other purposes including automating fiscal operations.

From a conceptual perspective, it would be possible to leverage the infrastructure provided by the central bank, if governments want to participate in the elaboration of the infrastructure's architecture. Splitting the value added tax (VAT) at the point of sale could be an interesting example. Channeling money directly from the government to the citizens, for example if a crisis were to occur, could be another interesting use case. We can also think about an automated distribution of social benefits.

According to Dr. Ousmène Jacques Mandeng (interview 8), cooperation between monetary and fiscal authorities in this area would be highly desirable. However, almost no government is involved in CBDC projects so far. Such involvement would be needed to ensure CBDCs meet not only monetary objectives but also broader policy goals. Anyway, programmable capabilities will be provided by the private sector, and not by central banks.

2.1.5 The cost of channeling cash

Some countries have also an interest in developing CBDC solutions because of their geographies. The Bahamas, for instance, is an archipelago constituted of 700 islands. Channeling cash money, ATMs and payment terminals to these remote areas comes with costs and risks. With the Digital Bahamian Sand dollar, the government ensures its most remote population's access to central bank money at the lowest cost possible. In some EMEs, even getting and holding cash can be dangerous. CBDCs could offer ways to enable safer and cheaper central bank money transmission channels.

2.1.6 The cost of sending and receiving money abroad

As we will explore further in part II of this thesis, sending money across borders is never free and is more expensive in the payments corridors experiencing less volumes. If these transactions can be made cheaper, macro-considerations will have to be explored and weighed, as Marcello Miccoli, senior financial sector expert at the IMF told me:

"There are considerations in terms of capital flows. If cross-border transfers are cheaper, then the demand for them will increase, and the gross capital flows between countries as well. This is good and bad because bigger gross capital flows and lower transaction costs imply that there is a more efficient allocation of investments. However, this exposes also volatility because money can flow in and out very quickly, and volatility in terms of capital flows are bad for countries sometimes, because it exposes them to volatile exchange rates or to dry up of funds and this might be problematic.[23]"

This explains partially why international transfers moving from T+3 to T+1 or T+0 settlements necessitates deep investigations among the financial ecosystems.

Every central bank in the world has different strategic objectives when it comes to monetary policy and CBDCs. EMEs are more likely to build and adopt retail CBDCs earlier than more populated and complex jurisdictions. Careful attention must be paid in order to make the CBDC attractive, but not too much in order not to disrupt the banking industry which is doing its job well in advanced economies. The European Union, for example, is likely to take much more time to implement CBDC, because it will be a particularly slow and cumbersome process to implement due to the number of jurisdictions and non-harmonized laws to work with.

This list of motivations to issue retail CBDCs isn't exhaustive and can't be, as the technology is still in development. According to the experts I interviewed (see interviews 3, 4, 5 and 8), there are probably plenty of new use cases and business models that retail CBDCs could be designed to perform but there are a lot of unknowns. John Velissarios (see interview 5) used an analogy I found relevant to illustrate the difficulty to anticipate possible new use cases:

[23] Miccoli, M., Interview 11. P.50 of appendices

"I think there are a lot of unknowns here. It's like trying to predict, at the start of the internet, what the internet would be used for. In the beginning, people were looking and thought "wow, you can send e-mails it's fantastic", but now that is the smallest use case for it so I think we have no idea of what will be the impact -really we don't-, so predicting is quite difficult."[24]

With programmability features integrated in CBDCs, it should be possible to perform highly functional use cases through programmability of the currency or of payments. But this is not coming in the short term.

2.2 Commercial banks business model with the advent of retail CBDCs

In this chapter, we will try to figure out what impact the introduction of a retail CBDC could have on the business model of commercial banks and PSPs. We will discuss how regulators can ensure financial stability by avoiding financial disintermediation. The first thing to note is that central banks don't want to perform all the KYC compliance and customer-facing activities (see interview 6). This is why all the CBDCs pilots and designs I came across were based on a two-tier model where commercial banks manage the frond-end structure and central banks build and maintain the back-end infrastructure (see interview 5, 8).

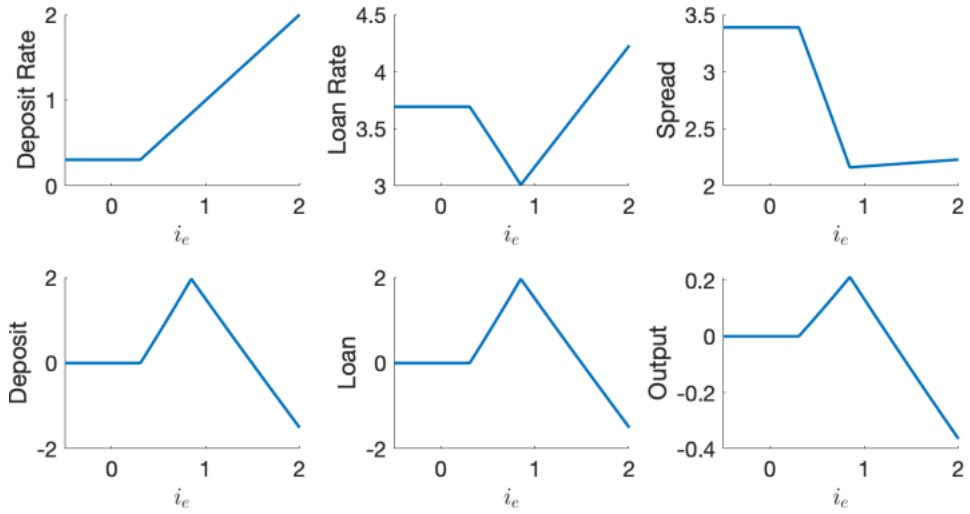
2.2.1 Interest-bearing CBDCs in a cashless world

A commonly raised concern about the issuance of CBDCs is that they would disrupt the financial intermediation provided by commercial banks. In a paper published through the Bank of Canada (Chiu et al., 2019), researchers came to the conclusion that the introduction of a CBDC doesn't necessarily imply bank disintermediation if the latter retain market power in the deposit market. Contrastingly, the offer of outside options to depositors could help banks to discipline their market power.

The study shows that, depending on the interest rate paid on CBDCs, deposit and credit creation could expand if the interest rates lie in an intermediate range. Bank disintermediation would occur only if such interest rates are set too high. In the model used by Chiu et al., banks are subject to imperfect competition, meaning that banks limit the supply of deposits in order to keep the interest rate on deposits below the competitive level. The outside option offered to depositors by the introduction of a CBDC sets a floor interest rate equal to the interest rate paid on CBDCs for bank deposits and reduces the incentive for commercial banks to restrict their supply of deposits.

[24] Velissarios, J., interview 5. P.23 of appendices

FIGURE 6: EFFECTS OF THE INTEREST RATE ON CBDCS



Source: Chiu et al (2019), P.44

The figure 6 here above shows in the upper panels the effects of changing the CBDC interest rate (noted ie on the x-axis) on the deposit rate, the loan rate and the difference between the latter as the spread. The bottom panels illustrate the percentage changes in deposits, loans and total output related to the equilibrium without the introduction of CBDCs.

In the horizontal part of these graphs, the CBDC interest rate is set lower than the prevailing deposit interest rate so that there are no effects on the equilibrium rates and quantities. Beyond this threshold, when the CBDC interest rate rises, banks are forced to raise the deposit interest rate up to the level of the CBDC interest rate. Higher rates are going to attract more deposits and, as long as the profit margin is positive, banks will be incentivized to use the extra deposit funding to provide more loans, implying a lower loan interest rate and thus a narrower spread. Output rises as a consequence of the higher investment.

In the last part of the graphs, where the CBDC interest rate is set so high that it cancels out banks' profits, any further increase in the CBDC interest rate will compel banks to increase the loan interest rate in order to break even, lowering deposits, loans and output.

2.2.2 Non-interest bearing CBDCs in a cashless world

Interestingly, even non-interest-bearing CBDCs can help restrain banks' market power as the cash use continues to decrease over time (Chiu et al., 2019). Currently, cash is in direct competition with bank deposits as a means of payment and a store of value. If online payments are to expand their dominance at the expense of cash payments, there is a risk that physical cash could in the end not be generally accepted as a means of payment.

If that scenario occurs, banks would gain additional market power, which could lead to higher fees, lower interest rates on deposits and sometimes lower quality of banking services.

Issuing a non-interest-bearing CBDC with basic payment features could ensure that depositors' external options are not worsened compared to the status quo.

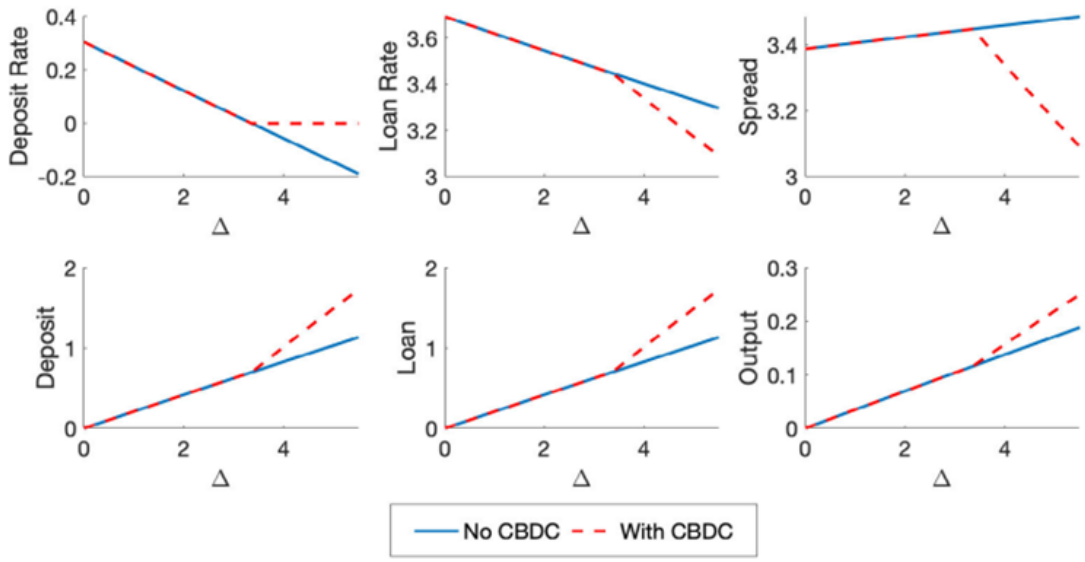
Such a CBDC could be a new, secure asset that could be used as an external option, like cash, as a store of value and as a method of payment. The existence of cash and CBDCs would bring a competitive pressure to banks, potentially prompting them to offer better terms and services.

Chiu et al. (2019) illustrate this idea in their model by assuming that a proportion, Δ, of sellers chooses to refuse cash. This can be explained through the growing fraction of e-commerce retailers which are conducting their business exclusively online, accepting only electronic payments.

They compare the equilibrium results with and without CBDCs as Δ increases. In Figure 7 here after, the solid blue line indicates the results without CBDCs. When Δ increases, banks gain additional market power as deposits become a better payment instrument than cash. As a result, banks can lower the interest rate on deposits because depositors always choose to hold more deposits which can now be involved in more transactions.

The red dashed curve represents an economy with a non-interest-bearing CBDC. Again, the CBDC forces a floor on the deposit interest rate. When the floor becomes binding, the CBDC prevents the deposit rate from becoming negative. In this case, banks will react by creating more deposits and providing more loans, which ultimately leads to higher output.

FIGURE 7: EFFECTS OF A NON-INTEREST BEARING CBDC WHEN THE ECONOMY BECOMES CASHLESS



Source : Chiu et al. (2019)

According to Marcello Miccoli (interview 11), CBDCs similar to cash in their properties (by non-bearing interests) are more likely to emerge in the sort term, because central banks want to avoid financial disintermediation. All sorts of considerations arise when thinking about interest-bearing CBDCs: "how much should it be? Should it be the same as central bank reserves? Different? What is going to be the transmission of these interest rates to the economy? There might be a stronger reaction and a stronger impact on the monetary policy from this perspective. Because changes in deposits' remuneration usually change in a longer and variable delay, and not instantly. With a CBDC, the change would be immediate".[25]

This is a subject that is still being investigated, and concrete answers on interest-related issues arising from CBDCs will be provided when the progressive deployments of CBDCs among the world.

[25] Miccoli, M., Interview 11. P. 53 of appendices

2.3 Consumer preferences related to the design of CBDCs

2.3.1 A study from the Official Monetary and Financial Institutions Forum (OMFIF)

In order to make CBDCs attractive to consumers, central banks should think carefully about the design of the CBDCs they intend to build. Key features that would make CBDCs attractive differ by jurisdictions, geographies and populations.

The OMFIF, together with G+D released a paper (OMFIF,G+D, 2021) in which they compared consumer preferences regarding CBDC's design between Germany, Indonesia, Nigeria and the US.

TABLE 3: CONSUMER PREFERENCES REGARDING CBDC'S INSUANCE IN FOUR COUNTRIES

What features of a CBDC would be most important to you? Select three.

% of responses, by country, ■ = greatest share of responses;

Source: Ipsos MORI, OMFIF analysis

	All	Germany	Indonesia	Nigeria	US
You can use a CBDC everywhere	**29.1**	13.9	**40.1**	**45.2**	17.0
Payments using a CBDC remain private	20.7	11.4	**38.3**	20.7	12.2
CBDCs are 100% secure	**33.0**	**23.1**	31.6	**51.0**	**26.2**
You can pay with a CBDC using your smartphone and at payment terminals	20.6	7.3	27.2	37.5	10.7
You can store your CBDC on a physical card	9.0	5.9	11.1	9.7	9.1
Paying with a CBDC does not require power or an internet connection	14.4	9.5	17.0	23.7	7.5
A CBDC is simple to use	22.3	13.6	35.1	27.5	13.0
You don't pay fees to use a CBDC	24.7	**23.2**	25.8	27.9	**22.1**
Payment with a CBDC takes place instantly	17.1	7.6	17.5	32.1	11.4
None of these - I would not consider using a CBDC	**23.3**	**43.9**	**7.0**	**2.7**	**39.4**
Don't know	13.1	17.5	11.8	5.5	17.6

Source: G+D, OMFIF, 2021, P.5

As highlighted in page 5 of the report, the key findings are the following:

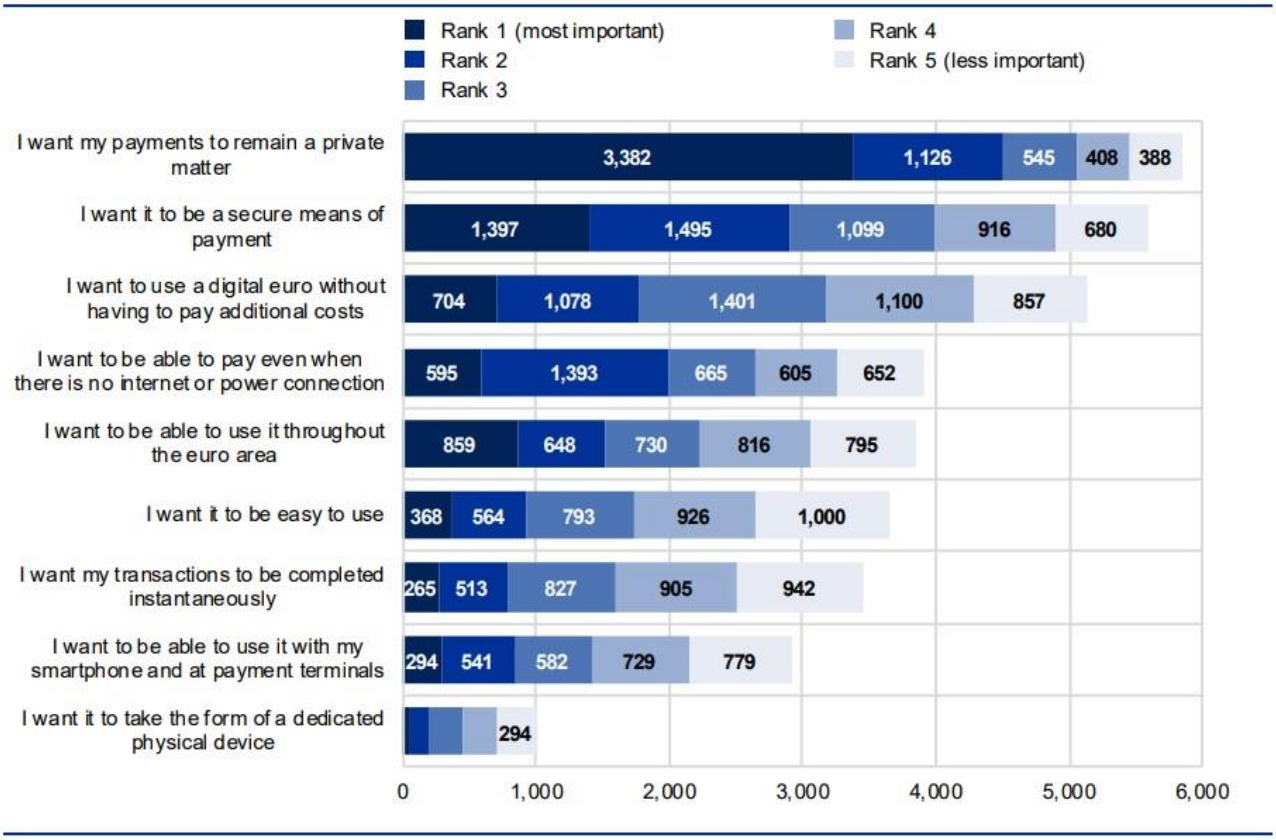
1) consumers in emerging markets economies are much more likely to view the potential of CBDCs favorably than those in developed markets, as EMEs' consumers could leapfrog by scaling up their digital payment opportunities without needing to pass by a card-ownership phase and move on directly to mobile apps, compared to consumers in advanced economies who are already provided with plenty of financial services and payment means. This explains why 43.9% of consumers in Germany and 39.4% in the US would not even consider using CBDCs compared to 7 and 2.7% of consumers in Indonesia and Nigeria.
2) Safety and availability are the main concerns for consumers overall, although individuals familiar with the concept of CBDCs value security as one of its key advantages.
3) Central banks have to work with the private financial service providers to ensure CBDCs to be widespread available for consumers, and educate them over the benefits in terms of convenience, security and low cost.
4) The vast majority of the consumers affirming that they would use a CBDC perceive it firstly as a tool for financial inclusion.

2.3.2 The ECB public consultation

The ECB launched a public consultation on a digital euro in October 2020 and released the findings of the consultation in 2021 (ECB, 2021). The sample of respondents isn't representative of the European population, as almost 50% of them were German and 87% were male but some results were insightful. 7761 citizens and 460 professionals participated in the consultation.

Nine questions were put to the respondents. They could rate these from most important (rank 1) to less important (rank 5). The results are illustrated in figure 8 here below.

FIGURE 8: PREFERENCES OF EUROPEAN RESPONDENTS RELATIVE TO THE DIGITAL EURO DESIGN



Source: ECB, 2021, P. 11

According to 40% of the respondents, privacy is the key feature they want a digital euro to provide.

Security, usability, low cost and accessibility are the other most popular features that respondents expect from a possible digital euro. The challenges identified by both citizens and merchants are related to privacy and ease of use as a means of payment. The latter also mentioned the poor internet penetration in some areas.

2.4 Comparison between advanced and emerging economies from a retail CBDC perspective

In this chapter, I will focus on the differences between advanced and emerging economies when it comes to a retail CBDC implementation. I will first define what are emerging and advanced economies, and then compare the motivations, the stages of implementation, the designs (when available) of retail CBDCs and present three different implementations in progress: in the EU, in Sweden and in Ghana. I chose these three "countries" because of the experts I managed to discuss them with: a digital expert from the NBB, an economist from the ECB, a senior advisor from the Riksbank and a business developer from G+D, a company that is working with the BoG for the eCedi implementation.

2.4.1 Distinction between advanced economies and emerging market economies

Through the releases of its world economic outlooks (WEO), the IMF sets out 3 criteria to assess the degree of advancement of a given economy. First, the income per capita, second, the export diversification and third, the degree of integration into the global financial system. The composition of each group can be found on the IMF website[26].

The situations and challenges faced by countries among the world related to financial inclusion, shadow economy, financial stability and payment systems' efficiency vary according to their degree of advancement.

2.4.1.1 Advanced economies

Advanced economies, characterized by a high income per capita, diversified exportations and great financial integration are listed in the table 4 here below. All the countries which aren't listed in this table are therefore part of the emerging market economies group.

Private payment service providers are more established in advanced countries than in their emerging counterparts. Consequently, authorities have an interest to build a public digital payment infrastructure which could constitute a backup payment system if a major crisis or disaster were to occur, preventing PSPs to offer their services.

TABLE 4: A LIST OF ADVANCED ECONOMIES

Major Currency Areas		
United States		
Euro Area		
Japan		
Euro Area		
Austria	Greece	The Netherlands
Belgium	Ireland	Portugal
Cyprus	Italy	Slovak Republic
Estonia	Latvia	Slovenia
Finland	Lithuania	Spain
France	Luxembourg	
Germany	Malta	
Major Advanced Economies		
Canada	Italy	United States
France	Japan	
Germany	United Kingdom	
Other Advanced Economies		
Australia	Korea	Singapore
Czech Republic	Macao SAR[2]	Sweden
Denmark	New Zealand	Switzerland
Hong Kong SAR[1]	Norway	Taiwan Province of China
Iceland	Puerto Rico	
Israel	San Marino	

[1]On July 1, 1997, Hong Kong was returned to the People's Republic of China and became a Special Administrative Region of China.
[2]On December 20, 1999, Macao was returned to the People's Republic of China and became a Special Administrative Region of China.

Source : IMF, 2021, P.89

[26] Retrieved from https://www.imf.org/external/pubs/ft/weo/faq.htm#q4b, March 2022

Advanced economies are, by definition, better integrated in the global financial system than EMEs. Therefore, financial inclusion is a much less crucial objective for the former than for the latter, even though the amount of unbanked households isn't trivial. Some improvements might be done in this area: in 2017, 3.6% of European households were unbanked. The numbers amounted to 7.5% of unbanked households in the US at the same time (ECB, 2017).

By contrast, maintaining financial stability and monetary sovereignty are more primary objectives for central bankers among advanced economies. As developed hereafter, the introduction of CBDCs would allow them to better monitor the state of a given economy in real time (CEPR, 2021). That being said, monetary sovereignty from a dollarization perspective is more trivial for advanced economies, and crucial to EMEs where their national currency isn't attractive enough compared to more competitive currencies such as the US dollar.

Although a CBDC could be designed to ensure the confidentiality of many individual transactions, the central bank would nevertheless obtain real-time information on the overall patterns of use and flows of digital money. This new information could improve monetary policy decisions and allow a more timely response to changing economic and financial conditions, particularly in times of financial stress (see interview 3, 6, 8, 10, and 11)

Keister and Monnet (2021) focus on one specific sort of information a central bank might be able to infer from CBDC flow data: the confidence that depositors and other creditors have in their banks.

In financial stressed times, financial intermediaries such as commercial banks hold private information about both the quality of their assets and the willingness of their depositors and short-term creditors to continue funding them.

A bank that is in a difficult position is likely to be able to obtain private information about the quality of its assets and the willingness of its depositors and short-term creditors to continue to provide funds to it. Nevertheless, such a bank will have an interest in hiding this fact from regulators, at least for a while, in order to avoid triggering supervisory action. The combination of banks' private information and the incentive structure thus leads to a delay in the response of policymakers to an emerging financial crisis (Keister and Mitkov, 2021). Such a delay can increase both the probability of a large-scale crisis and its severity.

When depositors and other short-term creditors know that the central bank will react more quickly to an emerging crisis, they have less incentive to withdraw from their banks. In other words, the ability of the central bank to infer information about depositor confidence has the effect of increasing depositor confidence at equilibrium. In this way, the information that a central bank would obtain by using a CBDC can increase the stability of the economy.

One of the most common fears regarding CBDCs is that by offering investors a convenient and safe alternative asset, the introduction of a CBDC will make bank runs more likely.

This effect is present in a study (Garrat, 2020), but it seems that it is offset by the faster policy response that CBDC allows.

The advent of CBDCs, if these are properly designed to avoid banking disintermediation, can increase the stability of the financial system by offering safer ways to pay in the digital era. Considerations over financial stability related to the issuance of CBDCs are investigated more deeply in advanced economies than in EMEs, because the former are very concentrated in PSPs, and the latter not.

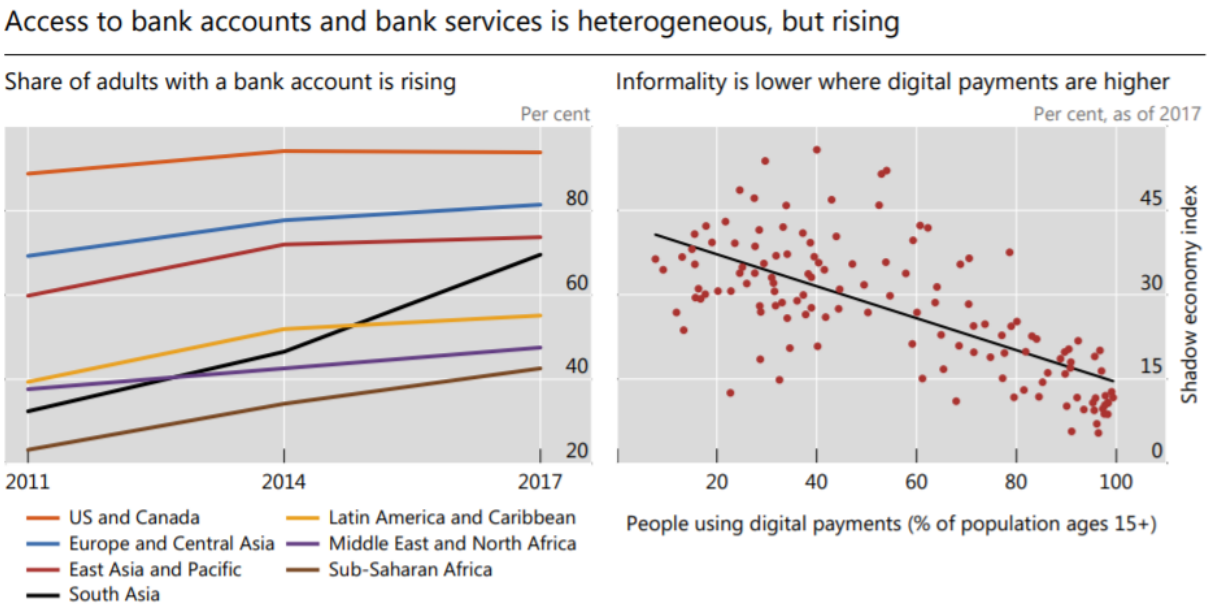
2.4.1.2 Emerging market economies (EMEs)

In 2021, EMEs accounted for 84% of the world population but only 37% of the world gross domestic product (Feyen et al., 2021). Inside money (i.e. commercial bank money) poses three key challenges to EMEs:

First, access to a bank account is essential. Even if it becomes more available, it is far from universal[27]. Several factors can explain this problem : the poor often lack appropriate documentation to comply with bank customer due diligence requirements, in some remote areas in can be difficult to access a bank branch, the minimum balances to hold in a bank account can be too high, as well as the maintenance fees. These factors imply that the population of such countries rely heavily on cash, which perpetuates informality.

In figure 9 here after, we can see that increasing digital payments lowers the size of the informal economy. In 2020, informality in EMEs could make up as far as 30% of the GDP, whereas it could reach up to 15% of advanced economies' GDP (Deléchat et al., 2020).

FIGURE 9: ACCESS TO BANK ACCOUNTS AND INFORMALITY IN THE ECONOMY



Source : Feyen et al., 2021, P. 5

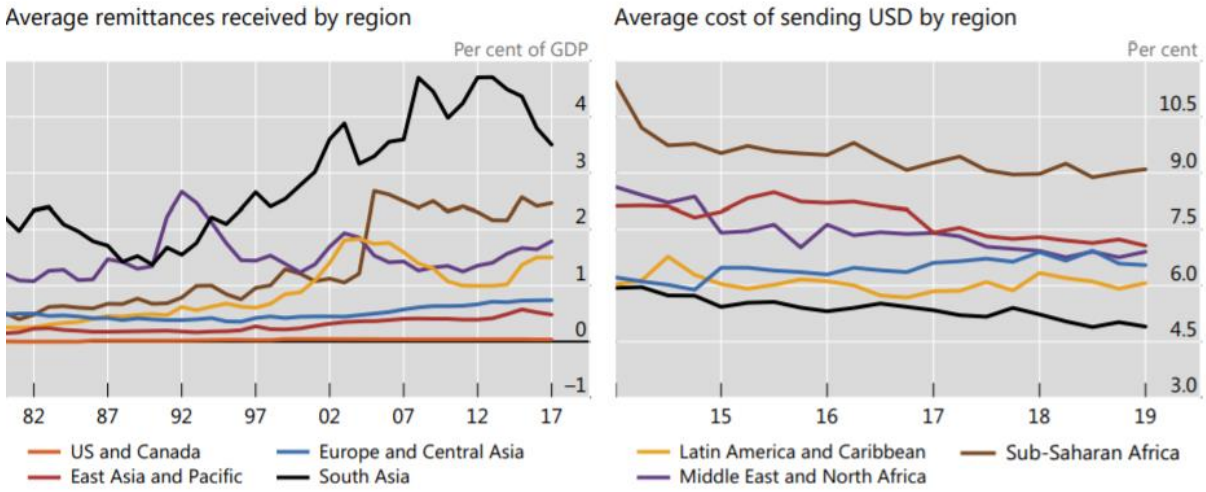
[27] See figure 9A here after

Second, financial institutions in EMEs generally face limited competition, resulting in more expensive financial services for households. Despite some improvements, this concentration reduces the incentives for new entrants to innovate and triggers a lack of trust in the financial system.

Third, many people in EMEs rely on remittances sent by relatives working abroad. These cross-border flows reached $551 billion in 2019 for EMEs (Feyen et al., 2021). This amount is three times higher than the official development assistance (World Bank, 2022) and explains the incentives EMEs have to reduce the costs of receiving remittances.

To reduce the costs and the latency of such transfers, specialized money transfer operators have emerged. Still, in Q3 2021 cross border transfer remittances cost on average 6.3% of the amount sent (World Bank, 2021).

FIGURE 10: REMITTANCES' FLOWS AND COSTS



Source : Feyen et al., 2021, P. 4

Thanks to having less stringent regulations implemented, EMES should take the opportunity to benefit from their relative blank slate to accelerate the implementation of fintechs. Resistance from installed players tends to be much weaker in such countries.

According to Eswar S. Prasad (Prasad, 2021), 6 factors make EMEs fertile ground for financial innovation:

1) The middle class is fast expanding in low to middle income countries, increasing the demand for higher quality financial services and products.
2) The small size of the majority of EMEs allows innovations to be scaled up faster, reducing transaction costs.
3) Financial regulators in EMEs seem to be more willing to implement such changes which would improve the current situation by a great factor[28]. They can leapfrog advanced economies without the need to implement proper legacy infrastructures.

[28] A great example of this reality is how Alipay met no resistance from Chinese financial regulators in the beginning, allowing them to experiment, innovate and quickly start to offer a wide range of financial products.

4) EMEs are less likely than richer economies to shelter large and powerful technological actors which would resist to change and technological progress or try to eliminate the new entrants. The barriers to start offering or receiving digital services is lower.
5) Many of the technologies behind financial innovation don't necessitate heavy investments in costly infrastructures, some of them having already been granted (IE : telecom based technologies)
6) The potential benefits of fintech innovations are greater in EMES than in richer countries. A greater part of the population there doesn't have access to the banking system, therefore lacking basic credit, saving and insurance products.

Moreover, regulations in EMEs are less stringent and complex to amend.

That being said, the availability of new cheaper channels when it comes to moving funds within and between countries could have major implications on the structure of the international monetary system, international capital flows and exchange rates. This could exacerbate volatility in the exchange rates and expose EMEs to spillover effects from the monetary policy decisions of major central banks (see interview 11).

EMEs strongly rely on their citizens working abroad, through inward remittances. Lowered costs of such transactions are an important source of funding especially for the poorest countries.

The regulatory power of EMEs is often much weaker than in richer countries, but the onus is on the regulators to anticipate and preventatively build a strategy helping them to harness the benefits of fintech developments mentioned here above, while keeping an active but cautious approach in mind. A passive approach increases the risks for EMEs to be victim of external decisions and technological improvements/ evolutions (Prasad, 2021).

2.4.2 Comparison between the Ghanaian eCedi, the digital euro and the e-Krona projects

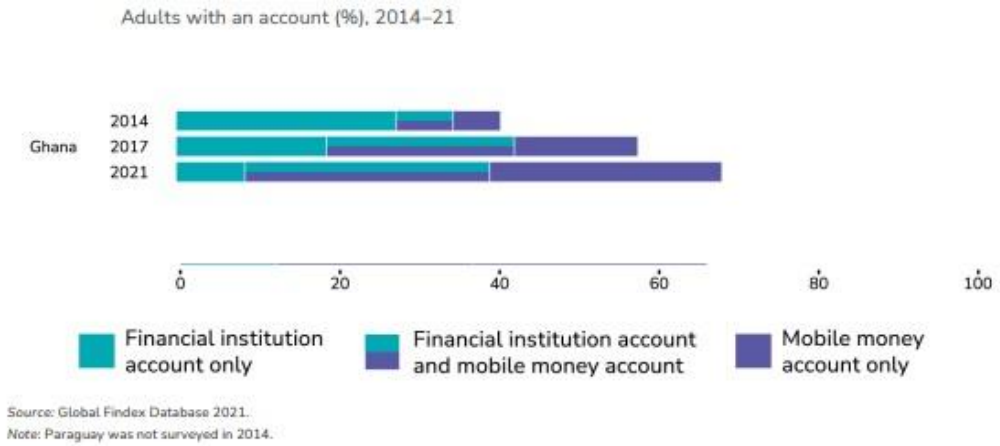
2.4.2.1 The Ghanaian eCedi

In 2019, the Bank of Ghana (BoG) declared its willingness to explore a CBDC solution (BoG, 2019). It was one of the first African central banks to state officially that they were working on CBDCs. The BoG mandated Giesecke+Devrient to conjointly build a retail digital Cedi (eCedi). Two factors triggered the start of this process : the improvement of private payment initiatives in the recent years, and the advent of the Covid 19 pandemic.

2.4.2.1.1 THE GHANAIAN FINANCIAL AND DIGITAL ECOSYSTEM

According to the World Bank (World Bank, 2021), mobile money account ownership has helped especially sub Saharan countries to boost their proportion of banked population. In Ghana, mobile money account ownership swelled from 13% in 2014 to 60% in 2021 while financial institution account ownership in Ghana remained mostly stagnant after 2017.

FIGURE 11: FINANCIAL INSTITUTION VS MOBILE MONEY ACCOUNT OWNERSHIP IN GHANA FROM 2014 TO 2021



Source: World Bank, 2021, P. 42

According to the same report, 37% of Ghanaian adults are saving through their mobile money accounts. 57% of Ghanian adults declared in 2021 having borrowed some money across the past year. Among these, 14% borrowed formally from a financial institution, 22% borrowed formally from a mobile money institution and 47% declared borrowing money only from their relatives. Family and friends are still the main source of credit.

The Ghana's ministry of finance released a digital roadmap in 2018 in which it indicated the direction that Ghana should aim to. According to it, 57% of the Ghanaian population was constituted of young adults between 15 and 34 years old, which fits well with the idea of implementing a digital agenda. In 2017, mobile phone penetration stood at 131%[29] of the total population.

From a financial infrastructure standpoint, "the country has built critical foundational financial market and payments infrastructure to aid the transformation into a "cash-lite" economy, including an ACH, a RTGS, a government integrated financial management information system (GIFMIS), a central security depository (CSD) with a trading platform, and ATM interoperability" (Ghana's Ministry of Finance, 2019, P. 9).

[29] Indicating that Ghanaians, on average, hold more than one SIM card

2.4.2.1.2 MOTIVATIONS TO ISSUE THE ECEDI

The motivations behind Ghana's interest in CBDCs are stated in the official report on the digital eCedi. It includes "facilitation of financial inclusion, pursuit of a cash-lite economy, enhancing operational efficiency and cost-effectiveness in payments, and provision of a safe, secure and trustworthy alternative to privately issued digital currencies." (BoG, 2022)

The formalization of the economy is also clearly expressed as an objective. A great share of the economy escapes beneath the radars and the development of mainstream digital payments is expected to shed light on this shadow economy, leading to improvements in the efficiency of fiscal operations and monetary policy transmission mechanisms. (BoG, 2022)

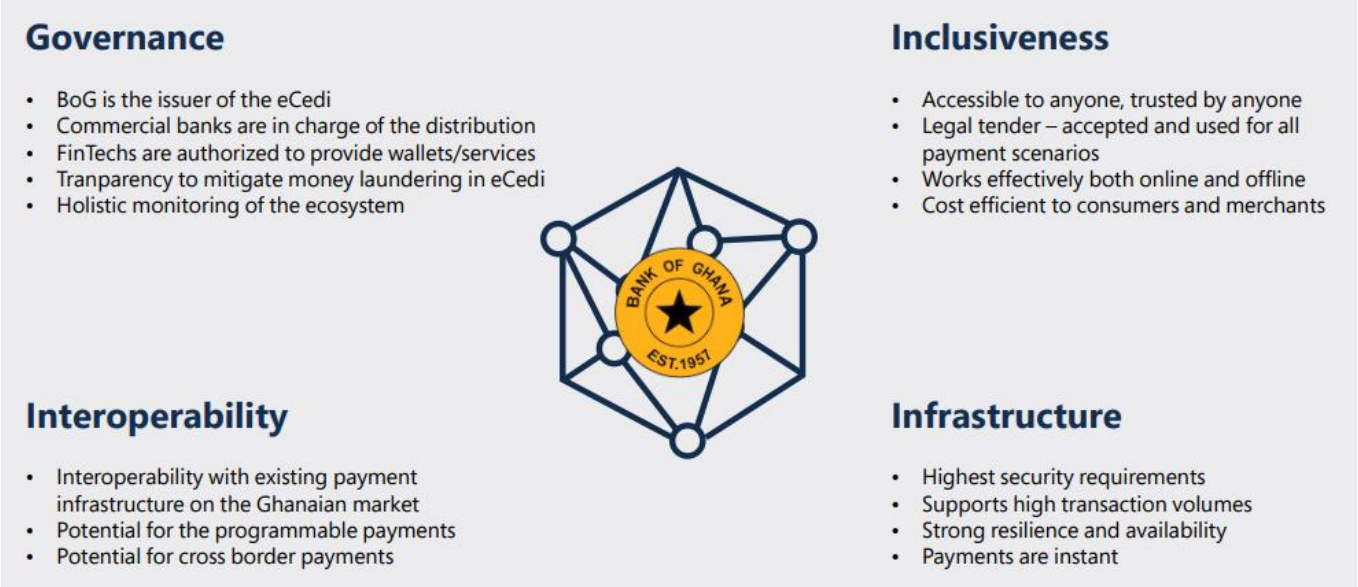
The introduction of a CBDC could help Ghana to attain strategic goals such as "increase digitization of the Ghanaian economy, foster financial inclusion and consumer adoption of digital payments, anticipate the future role of BoG as an active regulator and facilitator of a digital economy, foster the possibility of a more secure, efficient, and resilient payment system, address the risk of unregulated privately issued digital "currencies" or virtual assets." (BoG, 2022)

2.4.2.1.3 ARCHITECTURE & DESIGN

The eCedi is designed to be a retail token-based CBDC (BoG, 2022). The BoG is planning to release two types of wallets for the eCedi: hosted wallets privately managed by financial institutions and hardware portable wallets. The former requires an internet connection to be used while the latter works in offline mode. Due to the absence of internet networks in the rural areas, it is essential for the eCedi to work both online and offline.

The core principles of the eCedi's design are the following: interoperability, governance, accessibility and infrastructure. Moreover, the eCedi should be designed so that it offers a great user experience by providing ease of use and intuitiveness, which may help in fostering financial inclusion.

FIGURE 12: THE FOUR PRINCIPLES BEHIND ECEDI'S DESIGN



Source : Bank of Ghana, 2022, P. 25

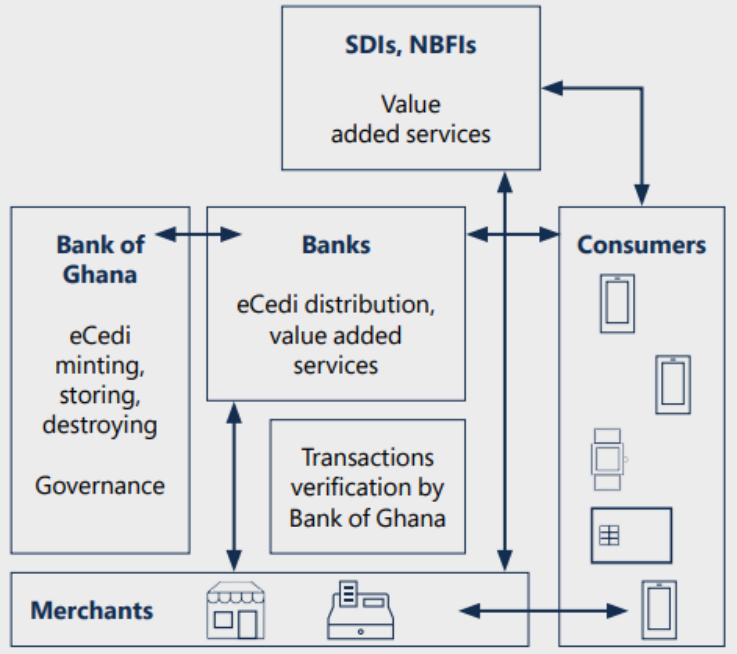
Governance

From a governance perspective, only one entity will be in charge of issuing, stocking and destroying eCedi tokens : the BoG; whereas banks, Specialized Deposit-taking Institutions (SDIs) and payment service providers will be in charge of monitoring the transactions as well as reporting suspicious activities to the Financial Intelligence Center and the BoG. Still, the BoG will monitor the transactions at the interbank level and issue policies.

In the two-tiers architecture proposed by the BoG, commercial banks will be in charge of the distribution of the eCedi to merchants and consumers. Where appropriate, they will offer value-added services such as mobile applications, asset custody or user-friendly presentation of transaction information. These institutions are best suited to develop these functionalities thanks to their experience in customer support and compliance with Know-Your-Customer (KYC) regulations.

Banks, SDIs and payment service providers will also be responsible for AML and CFT compliance. The figure 13 hereafter depicts the eCedi's infrastructure design.

FIGURE 13: ECEDI'S ARCHITECTURE



Source: BoG, 2022, P. 26

Accessibility

In order for the eCedi to be attractive, it should provide users with ease of use. This should help fostering financial inclusion. A payment should be possible to be done in the minimum number of steps, without the necessity of being financially or technically literate. Thanks to Ghana's consumer habits related to payments (mobile payments and cards are already used by a large extent of the population), the switching should be performed seamlessly.

ECedi payments must avoid reliance on mobile data networks accessibility as the Ghanaian rural areas are much less well served, when it comes to internet penetration, than more populated centres. Therefore, the eCedi is meant to work both on and offline. An offline eCedi could be implemented through the use of a smartcard, which G+D can provide. This low-cost solution is already being tested in Ghana (see interview 6).

From a consumer perspective, speed of payments also matters. Transfers from payer to payee should be performed instantly, with both protagonists receiving a confirmation of the transaction. The cost to pay should be competitive to existing market solutions. Like cash, eCedi transactions will be free of charge to the consumers. ECedi must be accessible for everyone, including people without bank accounts or high tech mobile devices.

Interoperability

Interoperability is required with the existing Ghanaian payment infrastructure. The eCedi will be integrated into the Ghana Interbank Payment & Settlement Systems Limited (GhIPSS) infrastructure, which is the payment infrastructure used by all banks in Ghana. ECedi`s integration with GhiPSS will allow the eCedi to run on a ready-to-use infrastructure instead of building a new one from scratch.

The mobile money landscape is also to be taken into account as there are already 38.5 million registered mobile payment accounts in Ghana. The interoperability between the eCedi and GhiPSS would enable settlements between different mobile money operators in digital currency, leading to improvements in speed and reducing frictions in settlements.

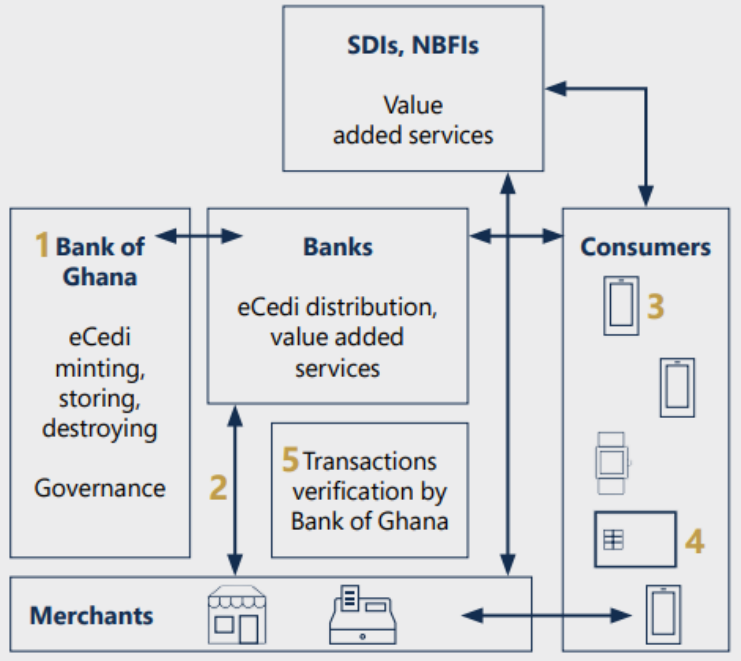
Interoperability is a key factor of success in the era of globalization. Domestic CBDCs should be designed so that it facilitates integration among African economies, particularly under the African Continental Free Trade Area (AfCFTA). This should make it possible for Ghana to collaborate on cross border CBDC projects.

On the programmability of the eCedi, the programmability of payments is privileged compared to the programmability of the currency. This means that new payment channels such as government-to-person, person-to-government or machine-to-machine will be kept in mind while designing the eCedi.

Infrastructure

The infrastructure supporting the eCedi needs to be resilient, secure, available and scalable in order to match the BoG objectives of reliability and resilience. In order to meet the highest security standards, the eCedi will be designed without any single point of failure. One of the eCedi's technical features to address cyberattack prevention is the separation of the issuance and distribution modules of the core infrastructure as depicted in figure 13 here above. The figure 14 hereafter illustrates this separation.

FIGURE 14: INFRASTRUCTURE SECURITY ASPECTS OF THE ECEDI



Source: BoG, 2022, P. 30

1. The creation and destruction of the eCedi is the most sensitive part of the system. The BoG is fully responsible for these tasks.
2. Highly secure communication channels between banks and merchants will be put in place.
3. ECedi apps providers will be given all the tools best suited to secure their apps against tampering and manipulation including frameworks and software development kits.
4. Smartcard security is based on different pillars:
    - Thanks to the entanglement of software and hardware driven inside a secure environment, the use cases of a smartcard are secure
    - Smartcards ensure the possibility of the storage and processing of data in a secure way and can be used as an endpoint in an end-to-end security system;
    - Smartcards can handle proper symmetric and asymmetric cryptography;
    - Hard- and software use a set of countermeasures to be resistant against security attacks;
    - The resilience against possible attack scenarios is investigated within security certification criteria.
5. The strength of the system's core protocol relies on the use of cryptographic algorithms and well established cryptographic components. The protocol has gone through phases of intensive investigations to demonstrate its strength.

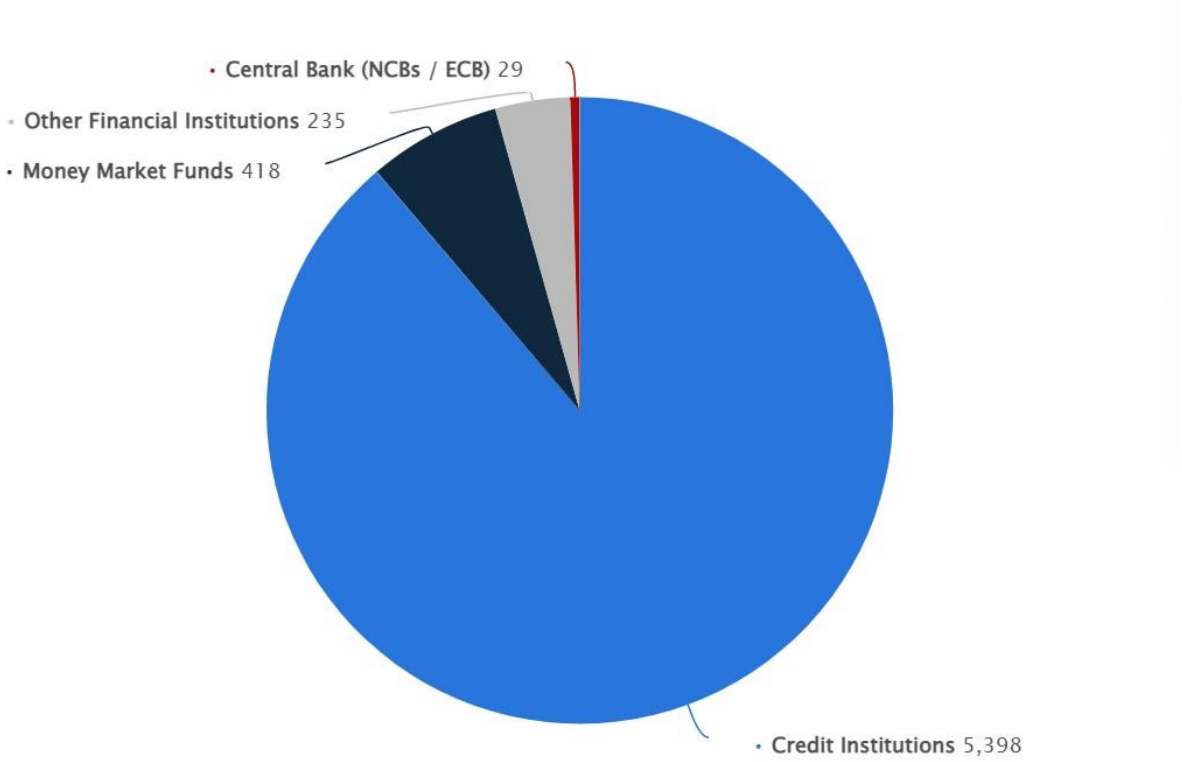
2.4.2.2 The digital euro

2.4.2.2.1 THE EUROPEAN FINANCIAL ECOSYSTEM

Since the introduction of the euro in 2002 and the establishment of the Single Euro Payment Area (SEPA) which started in 2008 and fully implemented in 2016, the European payment landscape is well integrated: European citizens and companies can send euro within the European borders to other European accounts with the same modalities of national payments.

A lot of institutions are managing the payment system in the EU. As of February 2021, there were a total of 6,080 monetary financial institutions (MFIs) operating across the 27 countries of the EU.

FIGURE 15: NUMBER OF FMIS IN THE EUROPE UNION AS OF JANUARY 2021



Source: ECB, 2021. Retrieved from https://www.statista.com/statistics/1111010/european-union-number-monetary-financial-institutions-by-type/, July 2022

Among them, several key institutions oversee the payment ecosystem:

- The European System of Central Banks (ESCB), also known as the Eurosystem, is composed of the ECB and national European central banks which are members of the eurozone. Its main objectives are to define and implement monetary policies across the euro area, to maintain price stability within the EU and to promote the European financial integration[30].

The ECB is also responsible for the well-functioning state of TARGET2, the European RTGS, and for the issuance of euro banknotes and coins performed through national central banks.

- The European System of Financial Supervision (ESFS), introduced in 2010, whose main objective is to ensure the harmonization of the rules applied to the financial sector across UE members. "The ESFS consists of the European Systemic Risk Board (ESRB), the three European supervisory authorities (ESAs) – namely the European Banking Authority (EBA), the European Securities and Markets Authority (ESMA) and the European Insurance and Occupational Pensions Authority (EIOPA) – the Joint Committee of the ESAs, and the national supervisors".[31]

-The Eurogroup brings the UE finance ministers together to coordinate economic policies. It is an informal body issuing statements and guidelines regarding economic policies.

- The Economic and Financial Affairs Council (ECOFIN) is responsible for economic policies, the regulation of PSPs, and taxation issues.

- The European Payments Council (EPC) brings PSPs together in managing the SEPA and helps fostering cooperation between public and private institutions.

This list isn't comprehensive but aims at addressing the complexity of the European institutional landscape.

2.4.2.2.2 MOTIVATIONS FOR THE EUROSYSTEM TO LAUNCH A DIGITAL EURO

The European payment ecosystem is well functioning as a great part of European citizens have access to digital means of payments aside of cash, which is available in all jurisdictions but whose availability differs according to the country.

The main trigger to start discussions and debates over a potential introduction of a digital euro was then not financial inclusion, but the announcement of Facebook, on July 15 2019, to launch Libra, renamed Diem in December 2020, a digital stable coin that Facebook users might send across the network. Due to the backlash from many central banks and financial regulators around the world, the Meta group officially abandoned the project to launch their stable coin in early 2022[32].

[30] TFEU, Art. 127§1
[31] Retrieved from https://www.europarl.europa.eu/factsheets/en/sheet/84/european-system-of-financial-supervision-esfs-, July 2022
[32] Retrieved from https://www.prnewswire.com/news-releases/statement-by-diem-ceo-stuart-levey-on-the-sale-of-the-diem-groups-assets-to-silvergate-301471997.html, July 2022

However, this event instilled fear among central bankers that a private actor releasing a stable coin would be able to displace central bank money in the long run (see interview 3). Parallel to that, the progressive decline in the use of cash also motivated the ESCB to ensure that riskless central bank money would still be available for European households to process their day-to-day operations, particularly in the situation where e-commerce is gaining traction.

The main motivation for the ESCB to issue a digital euro was therefore the monetary sovereignty. The offers of commercial bank money and payment instruments are not European. Visa and MasterCard, as United States companies have a strong hold on the payments traffic in our continent.

According to Axel Van Genechten (interview 3), If a geopolitical crisis were to occur, as of the invasion of Ukraine by Russia in February 2022, the sanctions applied to Russia could be equally applicable for the EU. Visa and Mastercard are not operating anymore in Russia. Hegemony from foreign countries in payment instruments basically means that we are strategically dependent on a small number of actors, and it also means that even if a hacking were to happen and bring down the Visa/ MasterCard traffic, European actors would be very vulnerable to this interruption. This, combined with the decline of cash, means that the European payment traffic might be halted or strongly impaired at certain points.

Major big tech companies or international banking consortiums could also develop new payment instruments. If these were to become adopted by great parts of the population with cash not being an avenue to pay anymore because less accepted, the reliance on foreign players that are not subjects to European rules would be enhanced further.

Developing a digital euro can help providing a necessary influx of competition so that the efficiency of the payment traffic remains intact. Aside from that, there are also ecological reasons: a payment system based on DLT might in some ways be a more energy-efficient and climate-friendly alternative than the existing means of payments.

In its report on the digital euro (ECB, 2020), the ECB projected potential scenarios that could lead to a need for digital central bank money, including the ones mentioned here above. The potentiality of a new channel of transmission for its monetary policy toolkit is also discussed in the report thanks to the possibility of applying negative interest rates to influence the consumption and investment choices of the non-financial sector, thereby eliminating the zero lower bond.

2.4.2.2.3 LEGAL CONSIDERATIONS REGARDING THE ISSUANCE OF A DIGITAL EURO

The design of the digital euro will determine its legal basis. As of late July 2022, no official statements have been released concerning the matter as all architecture types (token-based, account-based or hybrid approaches) are being explored and evaluated in relation with the Eurosystem's objectives.

However, privacy features are already known to be some of the most important features regarding the launch of a digital euro[33].

According to Johanne Evrard (interview 10), the European Commission will issue a proposal in the first quarter of 2023, which will define the issuance parameters of the digital euro. Co-legislators such as the European Parliament and the Council of the European Union will then play their roles in the debate. The mandate of the ECB is, in principle, not likely to be amended. The focus will rather be on the amendment of the legislative framework as it exists today in order to create a legal basis for the issuance of a digital euro.

According to Axel Van Genechten (interview 3), articles 127, 128, and/ or 133 of the TFEU should be used or amended to establish the legal basis for the issuance of the digital euro.

The Market In Crypto-Assets (MICA) regulation is currently debated between the European parliament and the Council presidency[34]. This proposal of regulation aims both at protecting the crypto-assets holders, including stable coins, and at enforcing AML regulations further. According to Charles Cuvelliez (interview 2), MICA won't regulate CBDCs because these are not risky assets, and they won't raise AML issues. The regulation is likely to end crypto-related discretion by forcing entities exchanging crypto assets to collect the identities and data of the protagonists, and hand them over to the competent authority.

Aside from CBDCs, the European Commission launched a DLT pilot regime proposal in 2020 which aims at allowing some financial institutions to experience DLT on a small scale[35] (interview 12).

[33] Retrieved from https://www.ecb.europa.eu/press/key/date/2022/html/ecb.sp220330_1~f9fa9a6137.en.html, July 2022

[34] Retrieved from https://www.consilium.europa.eu/en/press/press-releases/2022/06/30/digital-finance-agreement-reached-on-european-crypto-assets-regulation-mica/, August 2022

[35] See 3.2: Securities settlement for developments on the DLT pilot regime

2.4.2.3 The e-Krona

2.4.2.3.1 THE SWEDISH FINANCIAL ECOSYSTEM

Sweden is one of the countries of the world that is experiencing the fastest decline in cash use. The shift toward a cashless society was the main driver for the Riksbank to start investigating the CBDC potentialities. Several factors can explain the celerity of the decline in cash use in Sweden:

- The control mechanisms and the trust that Swedish consumers put in banks and other PSPs: the barrier to start using and offering new payment services is low.
- The expansion of the internet penetration and of the knowledge base related to digital payments literacy: a large part of the population has access to digital communications and is familiar with digital equipment. Moreover, the infrastructure needed to launch a digital payment service is available.
- The medium size of the market. The small number of banks of equal size dominating the Swedish market cooperated in the 40-50's to build conjointly the different financial infrastructures: they conjointly built the first ACH, own the ATM network and jointly built the digital identification services that the vast majority of the population is using now. Thanks to this multilateral building, these services are more usable for end-users, who can reach other accounts easily even if they aren't maintained within the same institution[36].

  In 2012, Swedish banks concertedly built Swish, which became the number one payment app in Sweden. Swish is used by 80% of the total population in Sweden, with more than 8 million accounts created, among which more than 265 000 companies[37].

These factors explain why the Swedish payment market is at the forefront of providing instant and user-friendly digital payments and why ease of use is also a prerequisite when it comes to the e-krona design.

[36] According to Björn Segendorff, "Denmark is a good counterexample: the first payment solution was made by the Danske Bank, which is by far the largest bank in Denmark. But they did it for themselves, meaning that you couldn't reach the other banks. That of course reduces room for maneuver for end-users." (See interview 4)

[37] Recuperated from https://www.statista.com/statistics/866139/number-of-swish-customers-in-sweden-by-account type/#:~:text=Swish%20was%20used%20by%20almost,customer%20was%207.13%20that%20month , July 2022

2.4.2.3.2 THE MOTIVATIONS OF THE RIKSBANK TO ISSUE AN E-KRONA

According to Björn Segendorff, senior advisor at the Riksbank (see interview 4), the first objective related to a potential e-Krona issuance is to ensure the general public access to central bank money.

The second motivation is to enhance the robustness of the payment system. Cash availability is key when it comes to crisis preparedness. According to the Riksbank, resilience has to be rethought in the digital age. The offline capability of the e-krona will therefore be key to ensure, even if the internet and the communications go down, that citizens have access to a safe payment means and are able to buy essential goods, if a technological disaster were to occur.

The third reason is to foster innovation and competition. The e-krona won't be just a new type of money, it will consist of a new financial infrastructure as well, on top of which private actors could innovate.

2.4.2.3.3 THE E-KRONA DESIGN

The riksbank worked with Accenture in 2 e-krona pilots in order to increase their knowledge on how the e-krona should be designed. They worked on the DLT platform Corda powered by R3. Several basic principles are mentioned in the pilot phase 1 report (Riksbank, 2021)

- The e-krona should be a claim on the Riksbank and not on the private sector. Banks and PsPs will operate a node in the DLT and should interact with end-users
- It should be a safe mean of payment
- It should deliver instant settlement and be available 24/7/365

In April 2022, the Riksbank released the e-krona pilot phase 2 report (Riksbank, 2022) with the following objectives:

- Involve real participants
- Test the offline solution
- Integrate with POS terminals
- Further test the performance

3 Part III: Wholesale CBDCs

In this part, I will focus on the implications of wCBDCs implementation for wholesale transfers, particularly from a cross-border perspective. Such transfers encompass various kind of transactions between banks and other financial institutions. These include transfers between financial institutions, but also securities settlements, and FX transactions. I chose to focus on these use cases because, according to the experts I interviewed, they are the most interesting regarding the advent of CBDCs. I will concentrate more on wholesale cross-border transfers, because the pain points of domestic wholesale transfers are also present in the cross border space.

3.1 Domestic wholesale payments

Most countries operate real-time gross settlement systems (RTGS), usually managed by the central bank (Prasad, 2021) in order to perform the domestic institutional transfers. In the eurozone the ECB manages TARGET2, while the Riksbank manages the RIX and the BoG the GhIPPS.

Two reasons explain why financial markets rely on such payment and settlement mechanisms. The first is the lack of trust between private banks, which compete with each other. The second is the resilience of public institutions which are not at risk of running short of liquid funds (Prasad, 2021).

Central bank money plays a key role in wholesale transfers, because it's the most riskless payment medium, and banks want to lower the risk to the largest extent especially in inter-bank clearing (see interview 8).

Domestic wholesale payments imply at least 4 types of transactions: the discharge of the obligation when you make the payment, the clearing, the netting at the background and then the settlement, performed by central banks through RTGS systems. If FMIs can project the cash properties on the digital space, implying that when the payment is being made, it is both payment and settlement in a unique transaction, it could allow far more streamlined processes to be put in place (see interview 5,7, and 8).

3.2 Securities settlement

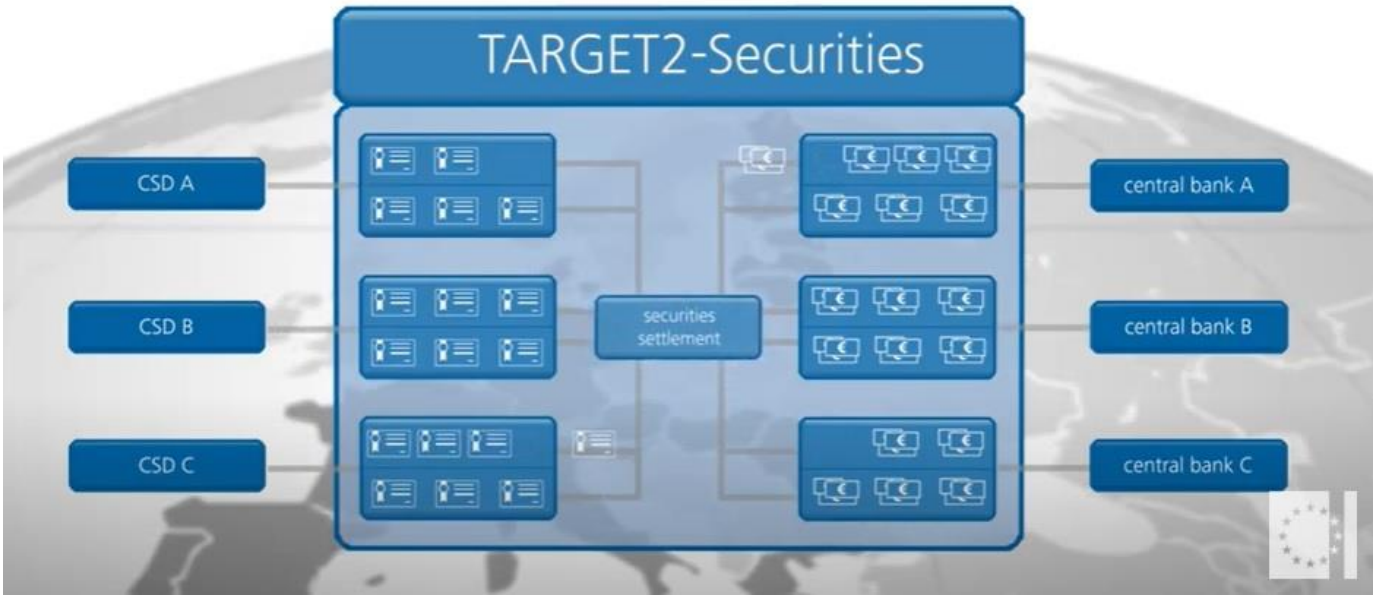
Cross-border securities settlements occur when the settlement of a security happens in a country other than the country of one or both counterparties (BIS, 1995). Nowadays securities are being held on central securities depositories (CSDs), which are usually managed by a public authority like a stock exchange or a central bank (see interview 12).

A direct remote access of foreign participants to local securities settlements and payment systems to execute cross-border securities settlement is often not feasible (NBB, 2006).

Generally, these settlements take place in the CSD of the country where the security is issued. CSDs maintain bank securities accounts and transfer securities from the seller bank account to the buyer bank account. At the same time, the central bank, through the RTGS system, transfers the selling price from the buyer bank to the seller bank. When different central banks managing different RTGS systems are involved, this is a cumbersome process.

In Europe, the establishment of TARGET2-securities (T2S) via the unified RTGS system eliminates the friction so that transfers happen as smoothly as pure domestic ones.

FIGURE 16: T2S AND CSDS



Source: Deutsche Bundesbank, 2018

But the problem remains for cross-border securities transfers implying non-European actors, because these don't have an account with the ECB. If access to central bank accounts were to be broadened, this situation could change drastically as different RTGS systems wouldn't have to be involved.

According to Nicholas Mallia (interview 12), who is policy advisor at the European CSD Association (ECSDA), CSDs are the last compartment of the settling process: after the netting and the clearing of the transactions, which happen at the ACH, CSDs are responsible for the notarization and the settlement phase. CSDs are there to serve the third layer function of the transactions. Nicholas Mallia used a metaphor that I found very relevant to illustrate the situation : the financial settlement system is like a compartmented tanker. It has been designed like this to avoid contagion risks: if one compartment sinks, it doesn't bring the whole system down with it.

Most of the time, CSDs are created by public authorities such as a central bank or a stock exchange. For instance, Euronext, the main European stock exchange, owns an ACH and a CSD.

But this doesn't mean that netting and clearing are being performed in the same entity: the stock exchange, the ACH and the CSD are part of a group which is constituted of separated entities.

With the advent of DLT, this situation could change (see interview 12). The European Commission introduced a comprehensive package of measures including the DLT pilot regime in 2020. This regulation aims to allow CSDs to become a DLT settlement service, and stock exchanges to become DLT multilateral trading facilities. This would mean that clearing would be instantaneous. In this scenario the CSD would be the trusted third party responsible for the functioning of the DLT, which suits CSDs well because they already provide the maintenance and the notary services today. Such improvements would be made possible by DLT, whose value proposal here is the collapsing of the netting, trading and settlement chain. This is more about DLT than about CBDCs.

As opposed to payment vs payment (PvP) transactions, such as FX transactions[38], that imply pure money transfers, securities settlements imply the delivery of assets. To mitigate the counterparty risk, these transactions are settled in delivery vs payment (DvP) transactions[39] where money and securities are transferred simultaneously, if and only if the payment has been made. DvP mechanisms in cross border securities settlements are usually performed through (I)CSDs and involve central bank money in order to avoid risks inherent to inside money[40]. In today's world "the settlement architecture requires the settling banks to be direct members of a central bank settlement system" (R3, 2021, P.5), regardless the use of central or commercial bank money.

The payments and the securities settlement cycles have to be synchronized. This can be done effectively, but it's complicated and cumbersome.

If securities were available in a token format, then a simple exchange of tokens could mean that there is an instant settlement or what is called an atomic settlement, meaning that both legs of the transactions have to be performed simultaneously in order to perform the transaction and the instant settlement. This could greatly improve the efficiency of how securities can be settled today, by both eliminating the open positions and the counterparty risks and by fastening the process involved.

According to Dr. Ousmène Jacques Mandeng (interview 8), CBDCs as a payment instrument are less interesting per se than the token's properties behind CBDCs.

In the international space, when a domestic financial institution wants to buy securities from a financial institution in another jurisdiction, other challenges are added to the list: it's not relying only on domestic (I)CSDs or RTGS systems anymore, but also on foreign FMIs to perform the settlement of the transaction.

[38] See 3.3.3

[39] Other methods of securities settlements exist, such as FOP (Free Of Payment) or DvD (Delivery versus Delivery), but such methods exacerbate the counterparty risks

[40] To use central bank money is less risky than using commercial bank money, because the former is a liability on the central bank whereas the latter is a liability on a commercial bank

3.2.1 Tokens and settlement

With a DLT-based CBDC, implying the use of tokens, this situation could completely change. In fact, in this space, the properties of cash are projected in the digital sphere, so that the token is the settlement, like the banknote exchanged implies settlement in the tangible world. When the payment of the token has been made, both payment and settlement have been performed. By contrast, if we think about how payments are being processed today, there are at least four types of transactions: "There is the discharge of the obligation when you make the payment,[…] clearing, netting at the background and then there is the settlement, typically in the large-value payment systems"(see interview 8).

Shortcutting the existing infrastructure by enabling a peer-to-peer (P2P) platform where such instantaneous settlements could be performed could facilitate payments and make them much more efficient, thereby eliminating or reducing the friction in wholesale transfers.

In today's world, most of the securities are digitized in some way but remain paper-based. Tokenized securities could improve securities settlement by enabling faster settlement, lowering the settlement costs and bolster risk management (see interviews 5, 7, and 8).

Having a CBDC on the same ledger as tokenized securities could also lower the potential delay of RTGS and nettled settlement (R3, 2021).

3.3 Cross-border transfers

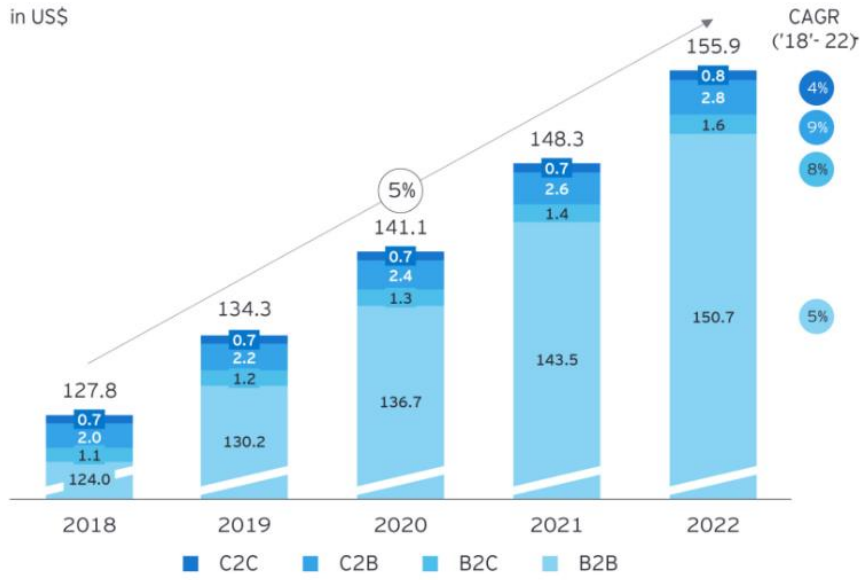
Cross border transfers encompass several kinds of transactions. In this part, we will focus on the correspondent banking system and on foreign exchange (FX) transactions, i.e. pure money transfers which imply PvP transactions in the cross-border space. I will then expose considerations regarding CBDCs and crypto-currencies.

3.3.1 Today's situation

In today's world, cross-border transfers are numerous and valued at trillions of euros per day (BIS, 2021). FX transactions alone accounted for $6.6 trillion every day on average in 2019 (BIS, 2019).

They cover four types of payments, namely B2B (wholesale), B2C (wages, interest payments), C2B (ecommerce), and C2C (or remittances) transactions. In this part, we will focus on the B2B cross-border transfers, which are by far the most valued share of transfers. We can see in the figure 17 here after the repartition in each cross-border transfer category. FX transactions are not included in the chart.

FIGURE 17: FORECAST OF THE SHARE OF DIFFERENT TYPES OF CROSS-BORDER SETTLEMENTS IN US$ TRILLIONS



Source: EY, 2021, P.5

In Cross-border transfers, national currencies actually never leave their own jurisdiction. Central banks issue money to domestic institutions and, therefore, money stays very local. These transfers rely either on international arrangements: through CLS for settling FX transactions, the international CSDs for settling cross-border securities transactions, and, for pure money transfers, the correspondent banking system, which is a network of intermediaries leveraging domestic arrangements.

Cross-border transfers occur when a transaction is initiated between actors of different countries. A number of factors make these payments complicated and long to process. They involve different currencies, so the exchange rate must be calculated at some point. Multiple institutions are often involved, adding their own fees in the transaction. The transfer needs to comply with different reporting requirements and financial regulations, which became onerous because of governments' will to counter money laundering and terrorism financing. Uncertainty is also part of the equation as it is more difficult to track payments that need to pass by several institutions.

These reasons make cross-border transfers cumbersome, expensive, risky, slow and complex to process. International transfers therefore come with friction and costs (see interview 5 and 8).

The lack of interoperability between payment infrastructures across the world due to securities legal definitions and standard differences also add to the complexity of such processes.

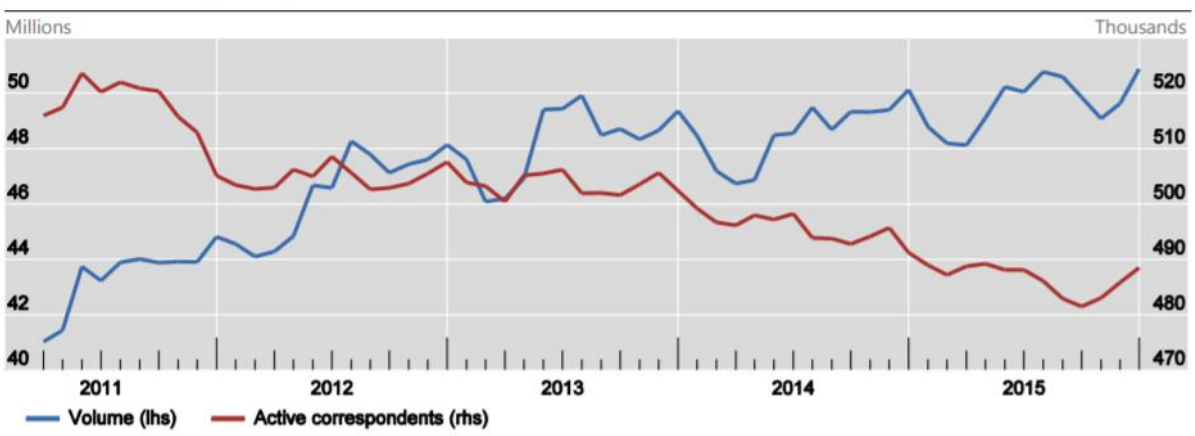
A particular problem of cross-border payments is the decline in correspondent banking, which is "an arrangement under which one bank (correspondent) holds deposits owned by other banks (respondents) and provides payment and other services to those respondent banks" (CPMI, 2016).

The transfer is performed through nostro (ours) and vostro (yours) accounts: a nostro account is the record maintained by the bank A that has money deposited in another bank B, which is part of a foreign jurisdiction. Bank B will label the same account as a vostro account, meaning that this account belongs to bank A.

The motivations behind the correspondent banking system lie in costs and benefits. If a bank in a given jurisdiction wants to send money to a foreign bank, it has two options: create a new branch in the foreign jurisdiction, or open an account in a bank within this jurisdiction. The latter option is the most cost-effective.

The decline in correspondent banking is illustrated in figure 18 here after.

FIGURE 18: THE DECLINE IN THE CORRESPONDENT BANKING OFFER VS THE INCREASING DEMAND



Source: CPMI, 2016, P.15

In the last decade, as we can see in the graph here above, correspondent banks became less willing to offer such payment services which are now perceived as very risky. Two factors can explain this trend:

First, because correspondent banks process large volumes of transactions for their customers' customer, it is more difficult to identify suspect transactions, as the processing institution lacks information on the actual parties conducting the transaction.

Second, this indirect relation implies that the correspondent bank provides services for individuals or entities for which it has neither verified the identities nor obtained any first-hand knowledge.

As a result of all these complications, cross-border payments are expensive, slow, difficult to track and cumbersome to process.

This situation is not the same everywhere. Depending on the currency pair we are interested in -or, the "corridor"- there might be more or less volume in transactions, and more or less competition in the correspondent banks willing to process the payments (see interview 11). It will typically be cheaper to send money between two advanced economies than from one advanced economy to an EME. Correspondent banking works thanks to banks in different jurisdictions having accounts at each other. If an institution needs to pass by more correspondent banks in order to process the transaction, it will be slower, more expensive and difficult to track.

3.3.2 Cross-border transfers with CBDCs

As stated before, there are mainly four challenges inherent to cross border transfers as they are being performed today. These are speed, costs, access, and transparency (see interview 11). If CBDCs are designed so that they work 24/7 and don't need to pass through complex netting, clearing and settlement systems to process the last leg of the transaction, this could help to reduce the time needed to perform such transfers, their costs and their opacity.

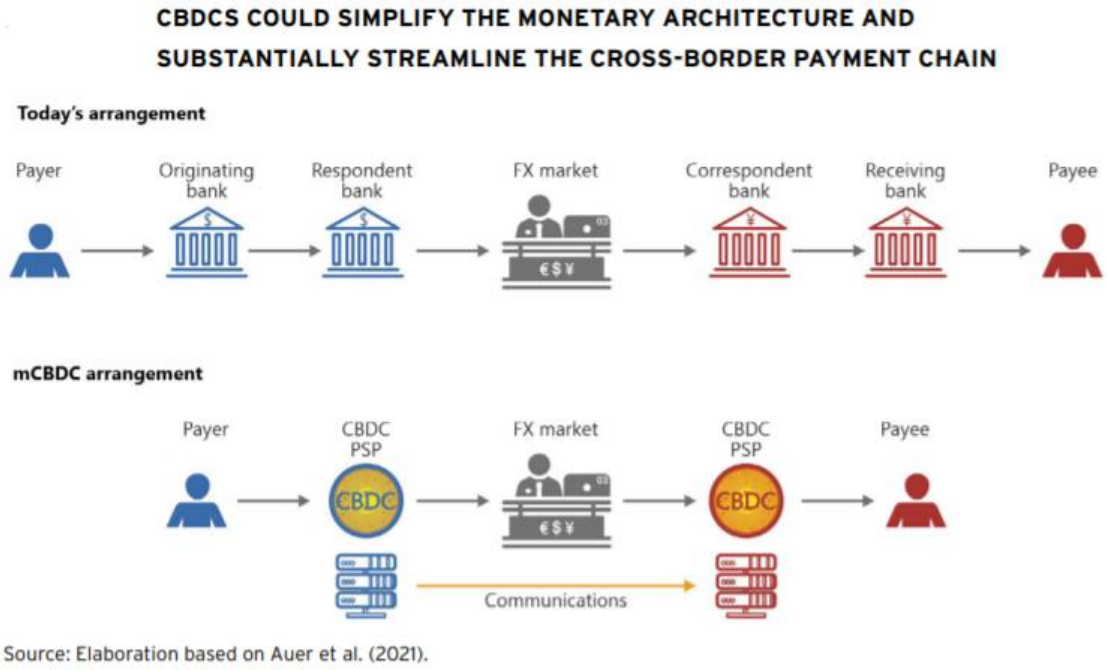
The costs involved in processing cross-border transfers should decrease, especially for less competitive corridors which rely on more intermediaries adding their fees to the transaction costs. If a new public payment infrastructure is to be launched, it will also increase the competition among PSPs by decreasing the network effects of major payment players, thereby reducing their rents and the costs involved in cross-border transfers.

In terms of transparency, it's going to be easier to track what's going on with the money sent, because the new system will provide information on the state of the transaction to be operated. The payment messages will still be handled by SWIFT, which will ensure communication between CBDCs and legacy systems with the ISO 20022 norm[41].

The access perspective is the major impediment for CBDCs to take place in cross-border transfers. The central banks will need to give access to their balance sheets to non-resident institutions, which is on the agenda: The ECB explicitly stated that a digital euro could be held by non-residents (ECB, 2020).

[41] See 3.3.4

FIGURE 19: HOW CBDCS COULD STREAMLINE THE CROSS-BORDER PAYMENT CHAIN



Source: CEPR, 2021, P.36

3.3.3 FX transactions

Changing money, back and forth, between two currencies is the biggest business in the world (see interview 5 and 8). In today's world, such transactions are being handled through the correspondent banking system. FX transactions are either performed through CLS, which is a multi-currency settlement system based in the US owned by 71 settlement bank members , or in OTC markets by mutual agreements. Most of the value of these transactions is settled through CLS, which handled on average $3 trillion worth of transactions daily in 2020[42]. FX transactions as a whole covered $6.6 trillion daily in 2019 (BIS, 2019).

CLS is there to enforce PvP mechanisms in order to get rid of the settlement risk, such as CSDs do in DvP transactions. OTC markets are therefore prone to this risk because FX transactions are made of two non-simultaneous cash flows. CLS is there to ensure that you get paid only if you paid before. CLS is currently covering 18 currencies[43].

[42] Retrieved from https://securities.cib.bnpparibas/the-foreign-exchange-market-in-2020-three-benefits-of-continuous-linked-settlement-cls/, August 2022

[43] "Danish krone, Norwegian krone, Swedish krona, US dollar, Australian dollar, Canadian dollar, Hong Kong dollar, New Zealand dollar, Singapore dollar, euro, Swiss franc, British pound, Mexican peso, Hungarian forint, South African rand, Israeli shekel, South Korean won, yen". Retrieved from https://securities.cib.bnpparibas/the-foreign-exchange-market-in-2020-three-benefits-of-continuous-linked-settlement-cls/, August 2022

The US$ is by far the most dominant currency: in FX transactions, the share of the dollar reached 88% of all trades in 2019. Currencies of EMEs increased their market share to 25% of the global FX turnover (BIS, 2019).

As for securities settlements, CBDCs are more interesting as a new back-end payment infrastructure than as a means of payment per se. The token properties of CBDCs could allow instant payments and atomic settlements to take place, thereby eliminating the settlement risk and offer variable settlement windows (Mandeng et al., 2022). "CBDCs can offer an end-to-end, token-based lifecycle for securities and foreign exchange trading".[44] This would eliminate the need for transactions netting and clearing.

FX transactions and securities settlements are the most exciting use cases regarding CBDCs, because they are the largest users of central bank money.

3.3.4 The role of SWIFT in cross-border transfers

In today's world, SWIFT serves as a trusted intermediary facilitating cross-border exchanges. With the advent of CBDCs built on different technologies (DLT-based or not, account-based, token-based, etc.), SWIFT identified four roles that the institution could play, highlighted in a report published conjointly by SWIFT and Accenture (SWIFT, 2021). These are the following:

1) Provide cross-network support

SWIFT could help facilitating interoperability between CBDCs built on different technologies, with different infrastructures. They could also help with interoperability between CBDCs and non-CBDCs payment networks in the CBDCs' issuance and redemption processes, thereby orchestrating the transfers of reserves between RTGS systems and CBDC networks.

According to Patrice Buabua (see interview 13), this role will be the first focus area to experiment. Legal and logistic loopholes currently exist: how could a central bank relying only on legacy RTGS systems handle CBDCs without the appropriate infrastructure at disposal? In the case of a transfer between CBDCs and legacy currencies, an FX operation will have to be carried out to import cash in place of CBDCs but the procedures remain to be defined. As CBDC adoption progress, network effects will encourage financial regulators to tackle the issue.

Questions arise also on legal considerations regarding the transfers of CBDCs to a country having less stringent AML, CFT, KYC and consumer protection rules implemented. Prior harmonization of these rules will be needed to ensure a country's data are not at risk. These remain open questions.

[44] Mandeng et al., (2022). P.6. Retrieved from https://www.accenture.com/_acnmedia/PDF-174/Accenture-Revolution-Of-Money-3.pdf#zoom=50, August 2022

2) Provide CBDC application offerings

SWIFT could help reducing the costs of CBDC adoption by leveraging its kit of services and interfaces to interact with CBDC payment applications developed by the private sector on the foundation built by central banks.

3) Deliver critical network services

The international messaging network could leverage its trusted third party position to provide a range of network services, including providing transaction confirmation, notary services or helping to define the tokens' structure and properties.

4) Act as a central technical operator

SWIFT could leverage its existing network and infrastructure to provide the DLT network on which CBDCs are built. Although it would require changes to SWIFT's platform and infrastructure to provide a CBDC network(s) as a service. They will consider and evaluate this potential role as the CBDC ecosystem evolves.

Here is a summary of the different roles SWIFT could play in facilitating CBDC adoption:

TABLE 5: ROLES OF SWIFT IN CROSS-BORDER TRANSACTIONS IMPLYING CBDCS

Cross-Network Support	CBDC Applications	Critical Network Services	Central Technical Operator
Cross-Network Transaction Orchestration	CBDC Payment Applications	Identity Manager	CBDC Network(s) as a Service
Cross-network Transaction Facilitation (HTLC etc.)	Integration between CBDC Networks & Payment Systems	Trusted Directory Service	DLT Node Operator
Liquidity Distribution	CBDC Payment Transaction Orchestration	On-Boarding Service	Resilient, Trusted Network Infrastructure Provider
Interoperability Bridge	Provide Ancillary Services (KYC, AML etc.)	Network Map Provider	
DvP Securities Settlement Orchestration		Transaction Confirmation/ Notary	
CBDC Issuance and Destruction		External Information Provider (Oracle)	
		Define Token	

Source: SWIFT, 2021, P. 13

3.3.4.1 SWIFT's first experimentations

As mentioned above, the first experimentations conducted by SWIFT aimed at tackling the cross-network support issues. The goal is then to enable interoperability across borders, networks and payment systems. SWIFT has today an orchestrating position in cross-border transfers, which they project to build on to leverage their linking capabilities and management offerings.

As CBDC implementation matures for SWIFT and their customers, they will experiment on the other roles mentioned here above.

For their first experimentation, SWIFT assumed that some CBDCs would be based on DLT, while some others wouldn't. Given the fact that the DLT ecosystem is very fragmented, SWIFT also focused on making interoperability possible between different DLT platforms, such as the Corda platform powered by R3 and the Quorum platform developed by JP Morgan. For example, the Sverige Riksbank is building its e-krona on the Corda platform, while the HKMA is building on Quorum. There are of course plenty of other DLT platforms.

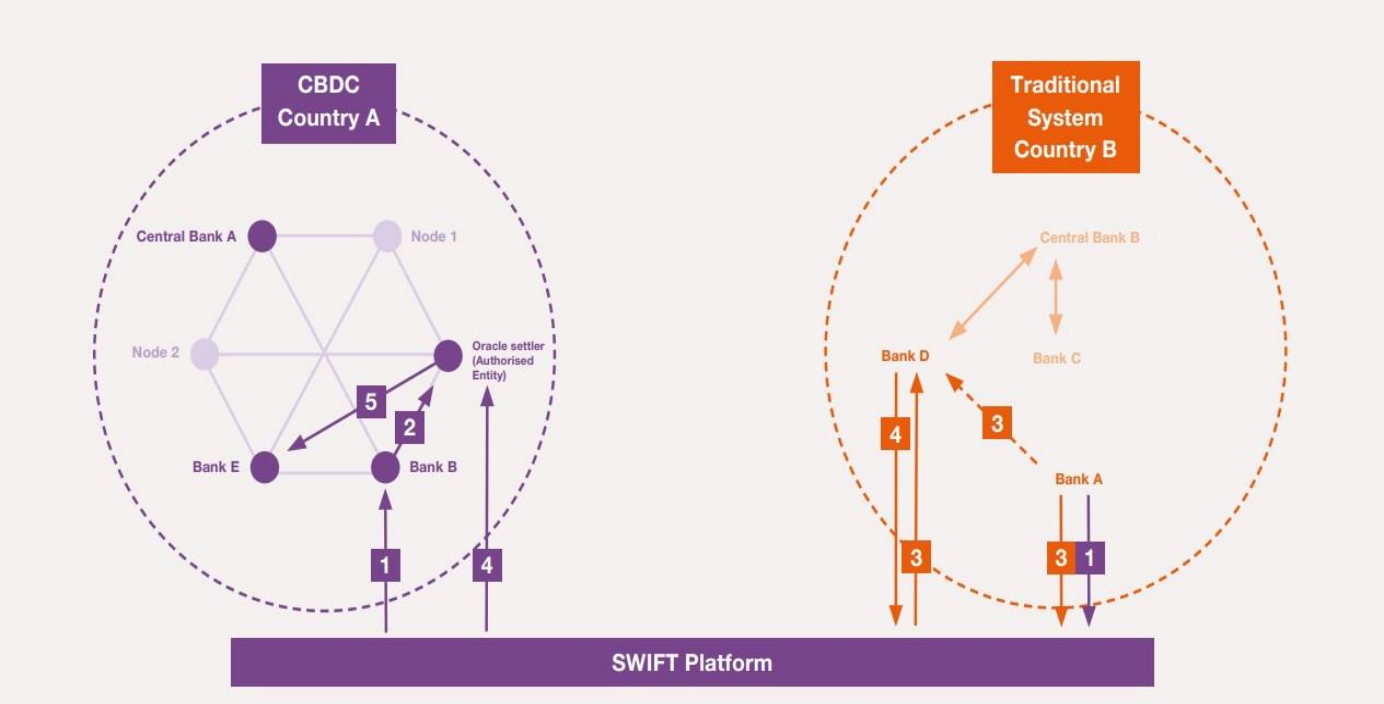
Because nobody knows which platform is to become the leader in the market from a mid or long term perspective, SWIFT decided to experiment the interoperability possibilities between different platforms.

3.3.4.1.1 EXPERIMENT A1

The goal of the first experiment was to showcase the possibilities for SWIFT to orchestrate cross-border transactions between a DLT-based network, and a traditional RTGS system. In order to eliminate the counterparty risk materialized by the exposure to default by transacting parties in escrow payments necessarily involving a trusted third party, they used a settler on the DLT, implying that funds were locked until settlement on the DLT network. The settlement then happens when the funds have been successfully transferred on the traditional payment system.

They performed a simulation, depicted in the figure 20 here below, where country A operates a CBDC network and country B a traditional wholesale infrastructure. A dedicated DLT network will be put in place to simulate a central bank's CBDC issuance. An additional traditional network will be created to simulate the wholesale payment system in country B. Then, the SWIFT platform will orchestrate the transaction.

FIGURE 20: OVERVIEW OF EXPERIMENT A1



Source: SWIFT, Accenture, 2021, P. 15

In this diagram bank A is part of a traditional wholesale network intending to transfer funds to bank E, which is running on a DLT-based CBDC network. Bank B and D are the liquidity providing intermediaries for the cross-network payment, whereas the settler on the DLT network is managed by a trusted third party authorized oracle running on a smart contract which will confirm the payment on the traditional network and then release the funds on the DLT-based CBDC network.

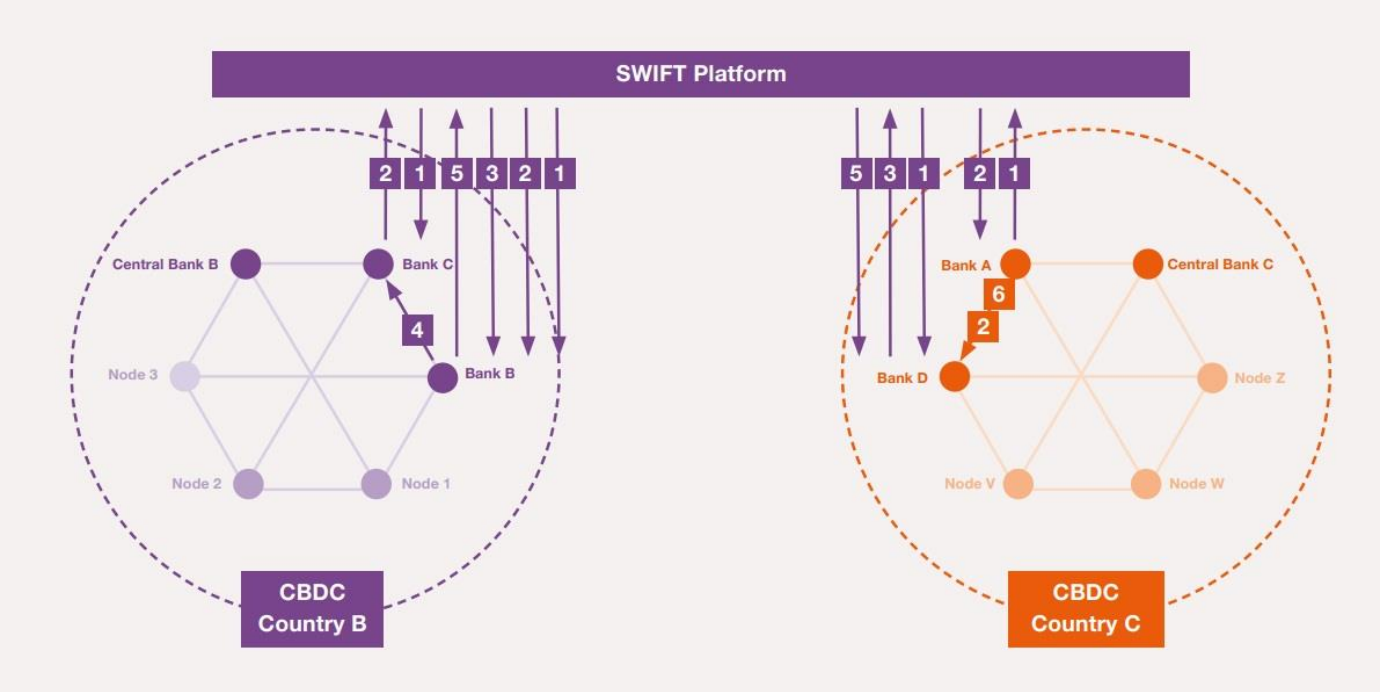
The following steps are mentioned in the SWIFT paper:

1) Bank A requests a transaction to Bank E at Bank B in the DLT network.
2) Bank B prepares the transaction and sends the request for confirmation to the settler, conditional to a successful deposit / transfer of funds on the traditional wholesale network of Country B.
3) 3. Bank A performs the payment to Bank D on the traditional wholesale network.
4) 4. Bank D sends a SWIFT confirmation to the settler after the successful payment by Bank A on the traditional wholesale network.
5) The settler cross-signs the transaction prepared by Bank B and releases the funds to Bank E concluding the settlement of the transaction."
6) The authorized third party oracle, by doing so, won't have the possibility to take possession of any value in the transaction.

3.3.4.1.2 EXPERIMENT A2

The goal of experiment A2 was to explore how SWIFT could orchestrate cross-border transactions between CBDCs based on different DLT networks (in this case, Corda, developed by R3, and Quorum, developed by JP Morgan), and to demonstrate the necessity to require SWIFT's services to perform such transactions through the correspondent banking system without the need to require trusted intermediaries to process PvP or DvP mechanisms. These were performed by smart contracts enabling atomic settlement.

FIGURE 21: OVERVIEW OF EXPERIMENT A2



Source: Swift, Accenture, 2021, P. 16

1) "Bank A communicates through the SWIFT network with Bank C (recipient), and Banks D and B, (correspondents) to align all parties and agree transaction details.

2) Bank C generates the pre-image and hash required to create and release the Hashed Timelock Contracts (HTLCs), IE the smart contracts. Bank A acts on this information to create the first HTLC transaction.

3) Bank D instructs Bank B to create the second conditional transaction, which would enable Bank C to access funds.

4) Bank B sets up the second HTLC transaction, allowing Bank C to sign it with the preimage and release funds to itself, revealing the pre-image on the ledger to Bank B.

5) Bank B extracts the pre-image from the ledger and communicates it to Bank D.

6) Bank D uses the communicated pre-image to sign the first HTLC transaction, releasing funds to itself and completing the transaction.

7) Bank B extracts the pre-image from the ledger and communicates it to Bank D" (Swift, Accenture, 2021, P.16).

SWIFT's experiments aimed at illustrating interoperability from a technical perspective. According to Patrice Buabua (interview 13), legal challenges remain to be solved. The next point will focus a concrete example of how transactions can be settled through CBDCs and DLTs in Project Jura.

3.3.5 Project Jura: a concrete example

Project Jura is a public-private experimental partnership. This project, organized by the BIS, BdF, SNB, and a consortium of private financial actors led by Accenture aimed at assessing the possibility of issuing a digital euro in France and then using it in Switzerland to settle transactions in central bank money in another jurisdiction. It was the first time this had been done in a digital format. The full report of the experiment was published through the BIS (BIS, 2021).

Concretely, a wholesale euro CBDC had been issued by BdF and a wholesale CHF CBDC by the SNB. Both the French bank involved in the experiment (Natixis) and the Swiss banks (Crédit Suisse and UBS) were considered non-resident by the jurisdiction they weren't part of. Yet, all of them transacted on the same platform (SDX), which is a licensed financial market infrastructure in Switzerland, and were able to hold wholesale CBDCs issued in the other jurisdiction. The transfer of funds to the central banks through their respective RTGS systems triggered the issuance of the wholesale CBDCs.

The transactions took place under the existing legal and regulatory frameworks of France and Switzerland, and not in a regulatory sandbox. Research and development have been performed by R3 on the Corda DLT to provide a dual notary signing capability.

The transaction flows involved the following steps in three days:

Day 1: 1) Natixis issued EUR 200,000 worth of tokenized commercial paper (NEU CP) and sold it to UBS.

2) UBS paid for the NEU CP with intraday euro wCBDC.

3) Crédit Suisse settled a FX transaction with CHF wCBDC against EUR wCBDC with Natixis.

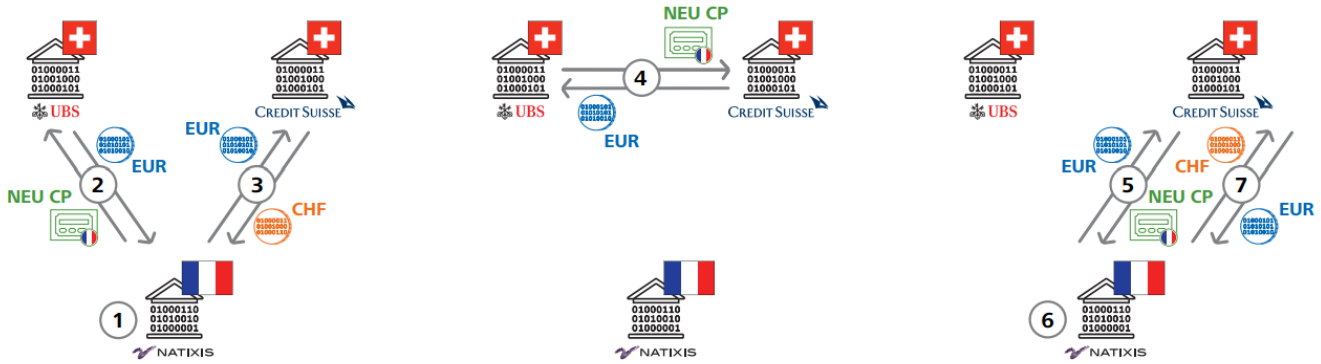
Day 2: 4) UBS sold the NEU CP acquired with Natixis to Credit Suisse against EUR wCBDC in a transaction on the secondary market.

Day 3: 5) Crédit Suisse redeemed the NEU CP to Natixis.

6) Eventually, Crédit Suisse exchanged EUR wCBDC against CHF wCBDC with Natixis in a FX transaction to return holdings to their initial positions on day one.

FIGURE 22: TRANSACTION FLOWS IN PROJECT JURA

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)



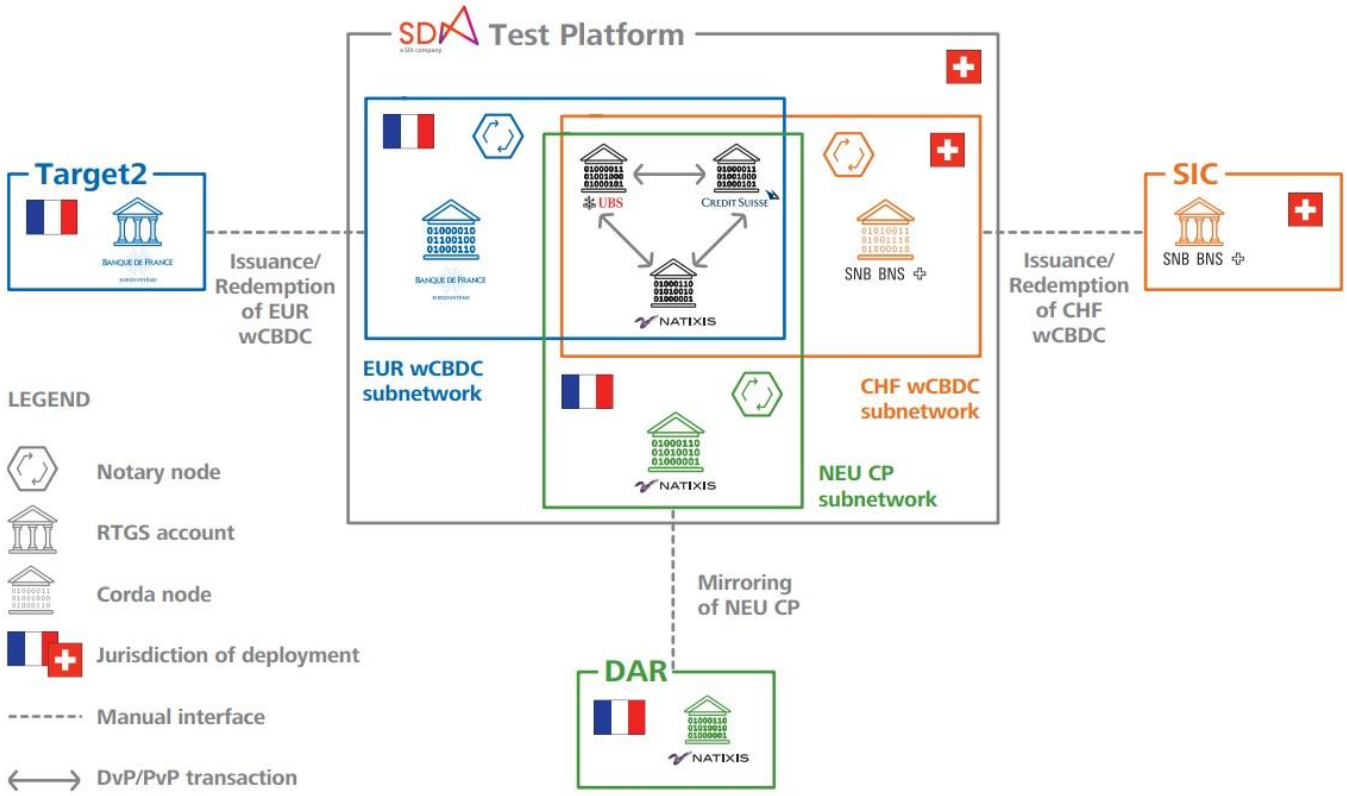
Source: BIS, 2021, P. 12

The architecture of the experiment involved four infrastructures, depicted in figure 23 on the next page:

Target2: The European RTGS system
SIC: The Swiss RTGS system
DAR: A new DLT based registry for tokenized commercial papers issued under French law
SDX: A DLT-based Swiss licensed exchange and central securities depository for tokenized assets

The first three allowed the issuance and redemption of wCBDC, NEU CP and final settlement of instruments to be processed effectively, while the SDX platform was where the PvP and DvP exchanges of these tokens took place, as well as the settlements of the transactions.

FIGURE 23: EXPERIMENTAL ARCHITECTURE IN PROJECT JURA



Source: BIS, 2021, P. 12

3.3.5.1 Lessons learned from project Jura

Three interviewees (5, 7, 8) have been directly involved this project and answered the questions I had after reading the report released through the BIS in 2021. They helped me to better understand its outcomes, which I develop here.

Project Jura investigated whether DLT can make cross-border settlements simpler, cheaper and faster using wCBDCs and how to build a concrete solution. It tested the cross-border settlement of a tokenized financial instrument as well as the settlement of FX transactions between the French and the Swiss national banks. This experiment took place in a near real setting, with value being effectively transferred involving a test platform of a licensed CSD for tokenized assets. The transactions were conducted using the current regulatory frameworks of both France and Switzerland.

In today's financial markets, settling these transactions involves numerous intermediaries and different payment and settlement systems. Project Jura demonstrated a more efficient and secure way to settle such transfers in central bank money with the help of DLT. Rather than interlinking three different platforms, the tokens circulated in a single platform (SDX) to which the three commercial banks involved in the project had access.

The world of financial market infrastructures is a highly siloed and fragmented world as many jurisdictions have their own financial infrastructure: Swiss has the SIC, the EU has TARGET2. The reason lies in the necessity for national regulators to control and monitor the transfers happening in their jurisdictions. In project Jura, such monitoring and control capabilities were successfully provided to the BdF and the SNB. Technical feasibility has been achieved, but legal loopholes remain.

In a nutshell project Jura

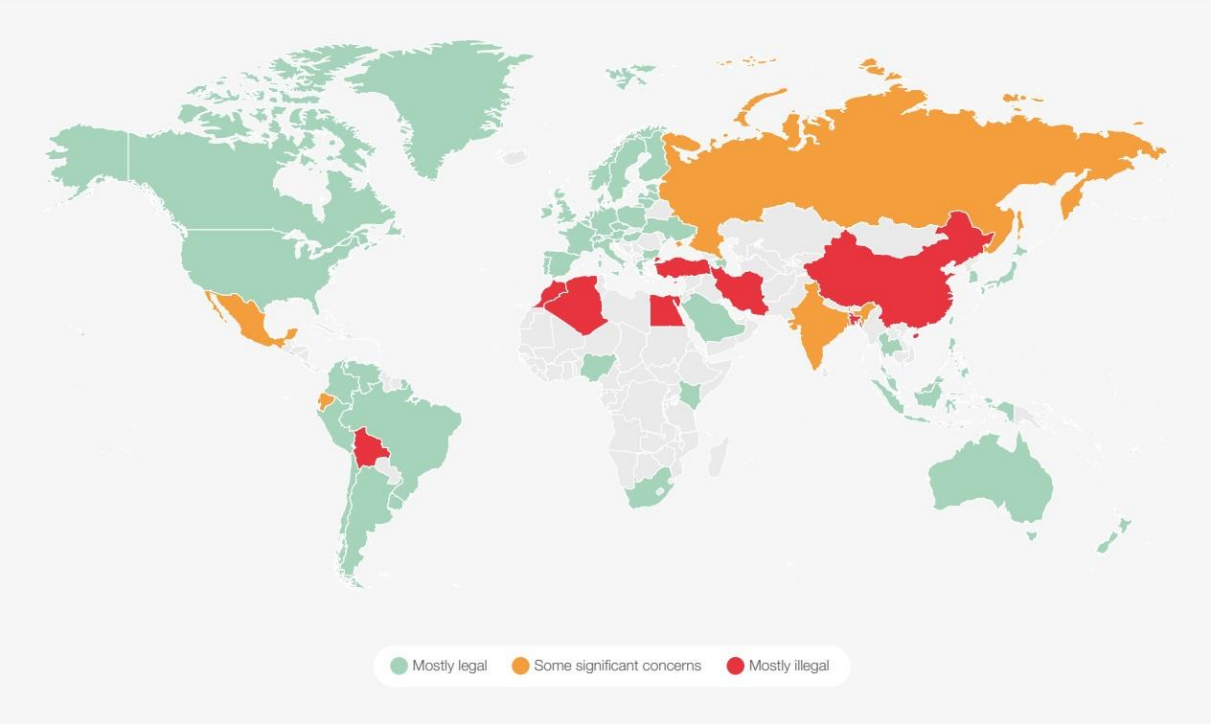
- Demonstrated a new way to settle tokenized securities and FX transactions across borders
- Worked under realistic conditions and implied real value transfers
- Extended the safety of central bank money to cross-border settlements by issuing wCBDCs to eligible resident and non-resident financial institutions.
- Provided national central banks with independent controlling and monitoring capabilities over their respective wCBDCs issued on a single platform
- Highlighted the legal impediments to overcome related to interoperability as the lack of harmonization between corporate laws among the globe and the absence of legal qualification regarding CBDCs (see interview 7).

3.3.6 CBDCs Vs Crypto-currencies?

I started to dive in the CBDC topic because I was wondering the effects it could trigger on crypto-currencies. As my investigations went further, I realized that these two types of currencies have completely different value propositions (see interview 11). CBDCs will be centralized, compliant with existing regulations and wont experience volatility, whereas crypto-currencies are decentralized, allow to escape these regulations to some extent, and experience huge volatility. The CBDC will be payment means, whereas crypto-currencies are speculative investing instruments.

The vast majority of countries around the world are tolerating the absence of crypto regulation (see figure 24 here below) but are working on this issue. The coming MICA regulation is an example in the EU of what kind of regulations are brought to the table, and will regulate crypto institutions providing financial services. MICA won't cover CBDCs. According to Charles Cuvelliez, who is cyber-security professor at the ULB (see interview 2), The discretion related to crypto-currencies is maybe about to being threatened. It will still be possible to send crypto under the radars through on-chain wallets, but not through exchange platforms. National regulations, such as MICA, are coming to regulate the firms offering crypto-related services. The extent to which, in a fully regulated world, complete privacy could still be achieved isn't known yet.

FIGURE 24: CRYPTO-CURRENCY REGULATIONS BY COUNTRY



Source: WEF, 2022, P.12

From a regulatory perspective, the WEF compared 4 scenarios of policy regulations: “Let the present trend continue, ban crypto-currencies, let them play a regulated role, or make crypto legal tender” (WEF, 2022, P.3) and encourages policy makers to let crypto-currencies play a regulated role in economies.

All the interviewees I asked the question “Are you a crypto-enthusiast and do you think that cryptos have a future?” answered favorably, despite working in what I perceived as crypto enemy institutions.

4 Part IV: contribution

In this part I will present the contribution of my work to the CBDC research and its limits. In order to bring some added value to my paper, I gathered the insights of experts involved in different financial ecosystems, with one common point: their experience, knowledge and focus on fintech and CBDCs. Here I will list every interviewee and summarize their inputs.

Interview 1: Bernard Nicolay, professor of financial markets at the Solvay Business School and at the ULB. He gave me insights on strategic aspects of the issues at stake with CBDCs for advanced economies, EMEs, central and commercial banks. He also helped me to better structure my thoughts and proposed me very interesting areas to explore.

Interview 2: Charles Cuvelliez, professor of cybersecurity at ULB and CISO of one of the top commercial banks implanted in Belgium. He wrote plenty of articles on the CBDCs' thematic and enlightened my view on technical features of wholesale payments, tokens, stable coins and CBDCs. He also introduced me to the coming MICA regulation.

Interview 3: Axel Van Genechten, digital currency expert at the NBB. He's working in the high level digital euro task force and taught me how the issues at stake with CBDC's implementation for the EU are being weighed by the ECB. He also provided me great insights on how policy decisions could affect financial actors in the European space.

Interview 4: Björn Segendorff, senior advisor at the Riksbank. He helped me better understand the reports released conjointly with other central banks through the BIS and explained very well what are the drivers for the e-Krona adoption and how Sweden became one of the most cashless society in the world.

Interview 5: John Velissarios, global managing director at Accenture. He helped me going through the different reports released by Accenture and provided me with great insights on the strategic considerations related to the choice of one technology or another. He also helped me to better understand the CBDC's programmability applications and how cross-border transfers are performed.

Interview 6: Polly Bäumler, business developer at G+D Filia. G+D released the design paper of the digital Cedi together with the BoG. She helped me better understand the drivers of the Ghanaian eCedi design and how this design should help the BoG reaching their strategic objectives.

Interview 7: Anonymous, advisor in the international banking industry. He's working on wholesale CBDC projects such as Jura and Helvetia and explained to me what are the concrete regulatory issues related to wholesale and cross-border transfers. He also depicted the implications of tokenized assets and securities settlements for wholesale transfers.

Interview 8: Ousmène Jacques Mandeng, senior advisor at Accenture and visiting fellow at the London School of Economics. He's been involved in projects Jura, Khoka II, M-Bridge, e-Krona, among others. He helped me to better understand monetary and fiscal policy considerations over retail, wholesale and cross-border problematics. He also provided me with great insights on the projects he is involved in.

Interview 9: Toan Nguyen, Hyperscaler manager at Micropol. He's been working for 10 years in the DLT space and helped me to understand the technical fundamentals of fintech, DLT and programmability.

Interview 10: Johanne Evrard, economist at the ECB, detached to the Eurogroup. She has been working for 10 years in the financial stability and financial regulation department within the ECB and is now working at the EWG, where the digital euro is a first importance topic. She helped me to understand the risks and opportunities related to the digital euro issuance.

Interview 11: Marcello Miccoli, senior financial sector expert at the IMF. Within the monetary and capital market department, he's been focusing mostly on the macro-financial impacts of digital currencies. He helped me to integrate both banking disintermediation considerations and cross-border transfers fundamentals, and to understand how CBDCs could help make these transfers more efficient.

Interview 12: Nicholas Mallia, policy advisor at the ECSDA. His experience in the European CSD Association helped me to better understand the CSD ecosystems, how securities are being settled today and how CBDCs could change the way such settlements are being performed. Thanks to his regulatory background, he also explained me very well what are the legal impediments to interoperability between different CBDCs and between CBDC and non-CBDC systems.

Interview 13: Patrice Buabua, legal expert and regional counsel in the financial sector industry. He helped me to understand macro considerations regarding CBDCs' interoperability and the coming ISO 20022 norm, and cross-cutting legal considerations regarding cross-border CBDC transfers and GDPR, AML, CFT, and KYC issues.

The number of interviews I managed to gather is restricted but this can be explained by several factors:

1) The confidentiality of the subject: in two years, I contacted by mail almost every central bank and financial institution interested in CBDCs. Only employees from the NBB and the Riksbank accepted to be interviewed publicly. I tried to reach to the ECB numerous times, but they kept answering me that the topic was confidential as most of their work is not yet public knowledge and that they were too flooded to spare some time for an interview.

In June 2022, I was lucky to discuss with a friend whose cousin has been an economist within the ECB for 10 years, and working on the digital euro implications for financial stability. This is how I got an interview from an ECB insider.

2) The early stage of the CBDC phenomenon: the CBDC topic is brand new and full of hypothesis. With CBDCs gaining traction, it should become easier to discuss the matter in the future thanks to the amount of future dedicated teams that will be implicated. At the moment these words are being written, the topic is still very prospective and definitive answers can't be brought to the table yet.

3) The technicity of the subject: only highly specialized experts can hold a deep cross-cutting conversation and provide meaningful insights on such an evolving and complicated topic as CBDCs. These high-level profiles are rare and very busy, thereby difficult to reach.

I based my methodology on a qualitative method rather than on quantitative analyses, because I was not in position to perform a collection or relevant quantitative data regarding the CBDC topic. However, in my opinion, the interviews I collected are very qualitative as they are all expert testimony and they made it possible for me to understand very technical subjects. To answer questions the reader may have, I suggest to explore the interviews, which develop some of the most complicated points mentioned in this thesis further.

To summarize my input, I wrote this thesis to provide its readers with a global perspective of how financial retail and wholesale ecosystems are working, and how they could evolve with the contributions of CBDCs. I tried to illustrate these with concrete examples, with the 3 countries I compared and with the experiments and projects I presented in the cross-border space. This paper gives food for thought on different but intricated topics. The insights of experts from very different backgrounds and working environments helped me -and the reader of this paper, hopefully- to perceive the issues raised in this thesis from different perspectives thanks to their financial, regulatory and/or technical backgrounds.

Of course, my contribution to the research has limits. In addition to the restricted number of interviews I managed to collect, I deliberately chose to focus on areas I perceived as most relevant.
For instance, when I compared the financial ecosystems of Ghana, Sweden and the EU, I found it more interesting to concentrate on the institutional landscape of the EU, which is likely to be one of the most complex regulatory framework of the world, on the digital landscape for Sweden, which is one of the most well served country from a digital service access standpoint, which explains why cash use is decreasing faster in Sweden than anywhere else, and on the evolution of the digital landscape for Ghana, which is I think well illustrating the situation faced by many EMEs currently.

Similarly, the design of the digital euro and the e-krona haven't been publicly released yet, so an effective comparison couldn't be proposed at the moment this paper is being written. Yet, I stressed differences on the policy choices that governments and central banks, depending on their jurisdictions, their digital landscape and the global state of their economy, are likely to focus on.
Among cross-border transfers, securities settlements and FX transactions are the two particular use cases I chose to focus on, because they are the biggest users of central bank money. Project Jura is a telling example where both securities settlements and FX transactions have been performed in cross-border transfers implying wCBDCs.

From the beginning of this work, I knew that its scope was maybe too wide for a thesis. Its subject is relatively abstract, and I didn't want to limit its contours too much in order both to try to understand it broadly and to be able to collect enough testimonies. Three reasons explain why I chose to widen this paper's scope.

First, at the start of this work, I was thinking about focusing exclusively on the e-krona or on the digital euro. But after months of continuous unsuccessful attempts to contact European or Swedish institutions and actors, I came to the conclusion that it would have been impossible for me to bring some added value through the gathering of interviews: I probably wouldn't have been capable of collect more than a few interviews on a too narrowed topic such as the e-krona or the digital euro. The supply of experts capable of handling a deep conversation on a very specified, technical and evolving subject is too low at the moment. Many respondents were skeptical that I would be able to gather 10 meaningful interviews.

Second, I was much more interested to tackle the whole topic of CBDCs than to focus on a particular implementation of some retail CBDC or just on the potentialities of CBDCs in relation with cross-border transfers. For as far as I remember, I have always been more keen to globalism rather than specialism. I am very curious and willing to understand macro-phenomena, and less inclined to investigate the micro sphere.

That being said, there are some CBDC-related fundamental areas I haven't explored in this thesis because I didn't find them essential to understand the issues at stake, thanks to answers I got on the questions I asked to the respondents. I am mainly thinking about the distinction between account-based and token-based CBDC, which are two different architectures. There are also other motivations for CBDC adoption that I didn't mentioned, because I thought that the theoretical developments necessary to understand them broadly would be too complicated for me to provide. I am mainly thinking about the increasing of seigniorage revenues and the reduction of environmental costs related to the management of less energy consuming and more efficient payment infrastructures.

I really struggled to contact EME's experts directly working in EMEs, but many of the respondents from the international banking industry I interviewed provided great insights over the EME topic. Among all the institutions and people especially involved in EMEs I tried to contact, only Polly Bäumler answered favorably to give me a Ghanaian perspective. I was much less knowledgeful and had less information at disposal regarding Ghana's situation and therefore chose to focus on the design of the eCedi rather than on the Ghanaian institutional landscape.
I also haven't explored some of the very interesting ideas suggested by Bernard Nicolay regarding possible use cases for CBDCs : « la possibilité de transférer des euros digitaux dans un pays non-démocratique pour financer des opposants politiques débancarisés. On peut estimer, en tant que parlement, que c'est une bonne idée. Pourquoi ne pas alors faire de concessions au niveau de l'anonymat ? Peut-être que des fonds seront acquis de manière illicite mais seront transférés pour des bonnes causes. Peut-on accepter ça ? Les débats sont ouverts.»[45].

I also hadn't the time to deeply investigate very interesting wholesale CBDC projects such as Khoka II, Helvetia, M-Bridge, Jasper-Ubin which aim at solving the interoperability technical challenges in different ways, and many others.
Another fundamental topic I haven't tackled is the rise and fall of the Ecuador CBDC, the Dinero Electrónico. I would have liked to address the subject, but I heard about it two days before the D-day of this thesis submission date, and I chose to focus rather on the coherence of the paper.

Structuring this thesis was the most challenging part for me, even a long time after I started to dive in the subject. Looking backward, I should maybe have separated the securities settlement part into domestic and international securities settlements, but the issues at stake in these areas were, I think, globally exposed. Understanding this thesis might be difficult for someone not interested in DLT and payment systems, but I tried my best to explain and synthetize how they work.

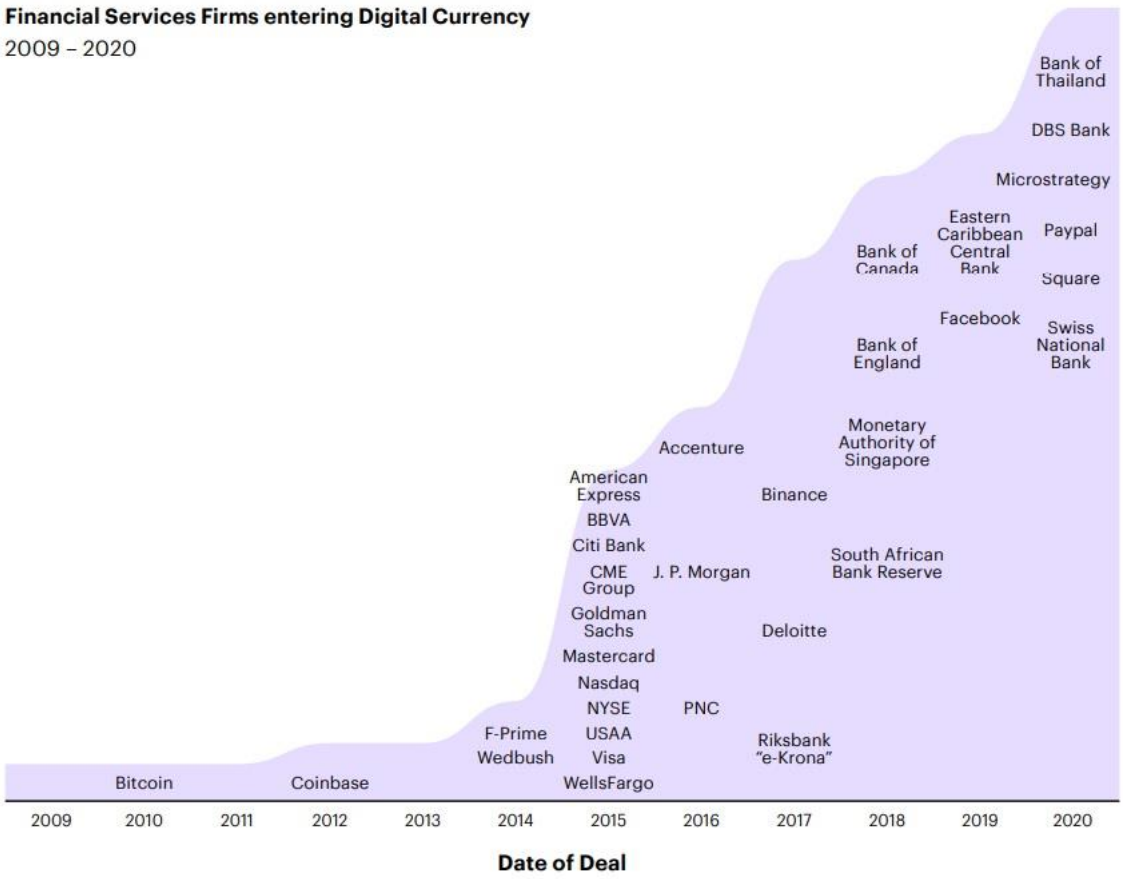
I considered this thesis as a passport to the world of employment, and I hope and think that it will come to fruition. My work helped me to understand both the financial landscape and the CBDC topic as a whole, and I think that this competence will be valuable in the employment market. I am obviously not an expert yet but I hope to become one.

For the moment, thanks to the restricted amount of people involved in this field, and to the potential it bears with it, I think that the competences and knowledge I developed by working on this paper will help me to find a working place where I can flourish.

[45] Nicolay, B. (2022). See interview 1

I am very enthusiast to candidate in international or national banking institutions, such as the ECB, the NBB, the IMF, the BIS, SWIFT, CSDs, the ECSDA, in private consulting companies working in the CBDC field such as Accenture, EY, G+D, Deloitte or McKinsey, or in commercial PSPs interested by the digital space. To illustrate the extent to which financial actors are entering the digital currency sector, here after is a graph depicting the evolution of interests among them as of late 2020.

FIGURE 25: FINANCIAL SERVICES FIRMS ENTERING THE DIGITAL CURRENCY SECTOR



Source: Accenture, 2021, P.5

Even in 2020, this list wasn't exhaustive. Since then, a lot of other financial actors and PSPs got on the digital currency train. I hope I'll manage to jump in!

5 Conclusion

This paper aimed at understanding considerations regarding the deployment of CBDCs for retail and wholesale payment markets. It's still a very prospective topic where investigations progress daily.

From a retail perspective, the CBDC topic is gaining traction at a rapid speed among financial actors, especially within central banks, which need to ensure the access to central bank money to their citizens in a world where payments become more digitized every day, thereby relying on commercial bank money, which is riskier because of the systemic vulnerabilities. The triggers for CBDC adoption are different in every country, depending on their institutional, financial and digital landscape, and many other variables such as geographies, the degree of formalization of the economy or the costs of sending or receiving money abroad.

EMEs are generally more aggressive in their work on CBDCs, because they have both less payments options and fast growing digital payment landscapes, with mobile money becoming predominant among used payment means. The financial inclusion is crucial for EMEs, because their population is more unbanked or underbanked than in advanced economies. That being said, the value proposition of a given CBDC will depend on particular conditions inherent to the issuing economy's situation, which will lead to peculiar CBDC designs.

However, when we compare advanced economies to EMEs' situation, main motivations, advancements and design choices, some trends can be inferred from the developments of this paper. These are of course not definitive statements and should be considered as continuums fluctuating country by country depending on their concrete situation. I sum up these trends hereafter.

TABLE 6: SUMMARY OF DIFFERENCES REGARDING CBDCS IN ADVANCED ECONOMIES COMPARED TO EMES

	EMEs	Advanced economies
Financial inclusion	Great part of the population is unbanked or underbanked, lacking access to basic financial services	Vast majority of the population is banked and has access to financial services.
Internet penetration and digital payments	Fast growing but still has room for improvement	Covering more than 90% of the population
Costs of retail cross-border transfers	Expensive and remittances account for a great part of the GDP	Relatively cheaper but still has room for improvement
Monetary sovereignty	CBDCs are perceived as a way to enforce de-dollarization and counter monetary substitution for countries willing to be monetary independent.	CBDCs can constitute a back-up financial payment system independent of private PSPs
Disintermediation risks	Not deeply investigated as financial integration through the banking sector is deficient	Deeply investigated as CBDCs should enhance financial stability and not disrupt the intricated financial ecosystem in place. CBDCs are likely not to bear interests
Formality of the economy	Informality makes up to more than 30% of GDP. Increasing digital payments can help to shed light on the shadow economy	Highly formal. OECD countries on average experiment informality up to 15% of their GDP
Consumer perspective	Mostly enthusiast	Mostly reluctant/ indifferent
CBDC deadline	Relatively short term, some are already deployed. A few countries are studying the topic	Mid to long term, but advanced economies' central banks are more involved than in EMEs
CBDC design	Often already released	Not public knowledge yet

Source: own conception

There are also common points between advanced economies and EMEs: in both cases CBDCs are likely to be built on a two-tier architecture, where the central banks build the back-end structure, and the private sector offer the front-end services, because commercial banks are already used to deal with customers, unlike central banks, and because the latter want to avoid banking disintermediation. A proper balance will need to be found there to assess the optimal degree of attractiveness CBDCs should offer. Such investigations will take more time in advanced economies, which rely on more complex banking ecosystems.

Privacy considerations will depend on the chosen design of CBDCs, but some consensus seems to have be found on the necessity of implementing transactional limits and thresholds, beyond which fiscal authorities will be granted an automated access to the payments data.

CBDCs are also a way to enhance competition in the payment market and the interest of the domestic currency, regardless of the advancement degree of the economy. From a legal perspective, EME and advanced economies central banks' mandates will need to be amended if CBDCs are to be equipped with properties that cash lacks.

The programmable features which would enable new use cases and business models to take off within the financial sector are being debated by central banks. It remains an open question, but we identified potential use cases such as programmability of the currency, programmability of payments, and automating fiscal operations. Programmable features won't be deployed in the short term as regulators want CBDCs to remain unencumbered.

From a wholesale perspective, financial institutions in advanced economies are also leading the research. As of mid-August 2022, this is still a very exploratory topic where experiments are conducted throughout the world to assess the feasibility, the challenges, the risks and the potentialities of wCBDCs. Particular attention is given to cross-border transfers, where four challenges have being identified by the G20 when designing their roadmap to enhance the cross-border payments: high costs, low speed, limited access and opacity. CBDCs can offer ways to alleviate these concerns and eliminate the remaining friction.

The cross-border settlement world is highly siloed and concentrated within national borders, which leads to fragmentation in payment systems and in law harmonization. Project Jura showed a way to enable controlling and monitoring capabilities for different central banks and a commercial bank on a single platform divided in sub-networks, by allowing the participating actors to sign directly the transactions in these sub-networks. This project and SWIFT experiments both highlighted the need for legal harmonization to avoid legal loopholes. Interoperability between CBDCs, or between CBDCs and legacy payment systems, today rises more legal than technical issues. The question of how a non-CBDC country should legally and technically manage foreign CBDCs without the appropriate infrastructure at disposal remains unanswered.

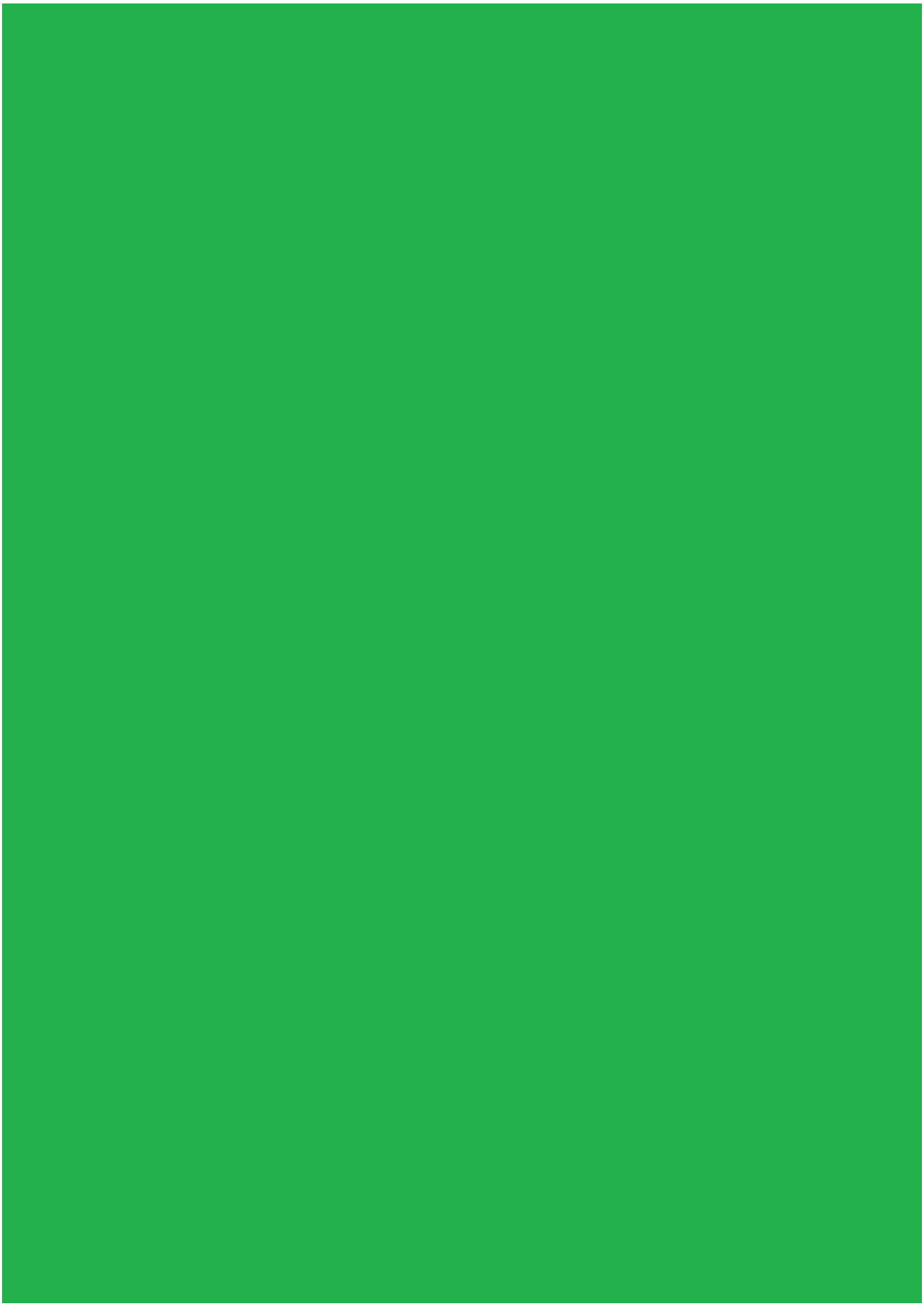
The correspondent banking system is sub-optimal because of the number of intermediaries from different jurisdictions involved. CBDCs could streamline the process, not as payment means per se, but because it would help to expand the access to central bank money to foreign financial institutions and reduce the number of needed intermediaries to perform cross-border transfers.

Securities settlements and FX transactions are maybe the most exciting use cases in terms of potentialities, because they are the biggest users of central bank money and because of the payment volumes they cover. The added value of CBDCs in this area lies in the token properties behind CBDCs, because the exchange of tokens would allow atomic and instant settlements to take place, thereby eliminating both the counterparty risk and the need to pass through different intermediaries such as clearing, netting and settling intermediaries.

From a crypto-currency perspective, CBDCs and cryptos don't offer the same value proposition. CBDCs will consist of new payment means, whereas cryptos are more used for speculative investment. CBDCs will be centralized, stable and compliant with existing regulations, while cryptos are decentralized, volatile and can help to circumvent the existing regulations.

To go beyond on retail payments, I suggest to pay attention to the central banks' increasing involvements in the area. Regarding some of the geographical focusing areas of this thesis, the European Commission is to issue a proposal for a digital euro legal framework in early 2023. The Sverige Parliament will have to deliver its thoughts on the Riksbank's mandate to issue the e-krona in November 2022. The eCedi pilot phase should start before 2023. Further investigations related to programmable features are also going to be essential to follow.

On wholesale payments, many projects not explored in this thesis have or are being developed: Helvetia, M-Bridge, Khoka II, Atom, to name a few. Further research exploring ways to eliminate legal impediments to interoperability between CBDCs built on different architectures and between CBDCs and legacy payment systems should also be followed closely.



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Glossary

- ACH: Automated Clearing House
- AML: Anti-Money Laundering
- API: Application Programming Interface
- ATM: Automated Teller Machine
- BdF: Banque de France
- BIS: Bank of International Settlement
- BoG: Bank of Ghana
- CB money: Central Bank money
- CBDC: Central Bank Digital Currency
- CCPs: Central CounterParties
- CDD : Customer Due Diligence
- CEPR: Centre for Economic and Policy Research
- CFT: Combating the Financing of Terrorism
- CISO: Chief Information Security Officer
- CLS: Continuous Linked Settlement, a limited purpose bank for settling FX transactions international payment system launched in 2002
- CPMI: Committee on Payments and Market Infrastructures
- CSDR: Central Securities Depositories Regulation
- CSD(s): Central Securities Depository(ies)
- DAR: a new DLT-based registry for tokenized commercial papers issued under French law
- DeFi: Decentralized Finance
- DLT: Distributed Ledger Technology
- DNS : Deffered Net Settlement
- DPSS: Decentralized Payment and Settlement Systems
- DTCC: Depository Trust & Clearing Corporation
- DVP: Delivery Versus Payment

- EBA: European Banking Authority
- ECB: European Central Bank
- ECSDA: European Central Securities Depositories Association
- EIOPA: European Insurance and Occupational Pensions Authority
- EME(s): Emerging Market Economy(ies)
- EPC: European Payments Council
- ESA : European Supervisory Authorities
- ESG : Environmental, Social and Governance
- ESMA : European Securities and Markets Authority
- ESRB: European Systemic Risk Board
- Etc.: Et caetera
- EU: European Union
- Fintech: Financial technologies
- FMI(s) : Financial Market Infrastructure(s)
- FX: Foreign Exchange
- G+D: Giesecke+Devrient, a German company that provides banknote and securities printing, smart cards, and cash handling systems
- GDP: Gross Domestic Product
- GDPR : General Data Protection Regulation
- GIFMIS: Government Integrated Financial Management System
- G7: Group of Seven, an inter-governmental political forum consisting of Canada, France, Germany, Italy, Japan, the United Kingdom and the United States
- G20: Group of twenty, an intergovernmental forum comprising 19 countries and the European Union
- HKMA: Hong Kong Monetary Authority
- HTLC: Hash-Time Locked Contracts. It is basically a payment wherein the receiver or the beneficiary is required to acknowledge the receipt of payment before a predetermined time or a preset deadline
- ICSD(s): International Central Securities Depository(ies)
- ie: id est

- IMF: International Monetary Fund - IOSCO: International Organization of Securities Commissions
- IT: Information Technology
- ISO: International Organization for Standardization
- KYC: Know Your Customer
- MICA: Markets in Crypto-Assets
- NBB: National Bank of Belgium
- NEU CP: Negotiable European Commercial Paper
- OECD: Organisation for Economic Co-operation and Development
- OMFIF: Official Monetary and Financial Institutions Forum
- OTC: Over-The-Counter
- P.: Page
- P2P: Peer-to-Peer
- PSD: Payment Services Directive (European Union)
- PSPs: payment service providers
- PvP: Payment versus Payment
- REFIT: The European Commission's Regulatory Fitness and performance program
- RTGS: Real-Time Gross Settlement
- SARB: South African Reserve Bank
- SDI: Specialized Deposit-taking Institution
- SEPA: Single Euro Payments Area
- SNB: Swiss National Bank
- SSS: Security Settlement System
- STX: Security Token Exchange, a Swiss-licensed market infrastructure platform
- SWIFT: Society for Worldwide Interbank Financial Telecommunication
- TSS: Trading Settlement Service
- T2S: TARGET2-securities
- UAE: United Arab Emirates
- UBS: Union de Banques Suisses

- ULB: Université Libre de Bruxelles
- UN: United Nations
- US: United States
- VAT: Value-Added Tax
- Vs: Versus
- WCBDC: Wholesale CBDC
- WEF : World Economic Forum
- WEO: World Economic Outlooks
- WFC: World Forum of Central securities depositories