Future of Money

A SIX White Paper

Foreword

As the backbone of the Swiss financial industry, we at SIX must understand the potential effects and relevance of the many developments we are currently witnessing — from new technologies, to political shifts, social changes, and business model innovations. White papers are one of the by-products of I&D's efforts in developing such scenarios.

The publication of this white paper serves several goals: to underscore the cultural shift going on at SIX, to elicit feedback from a broader audience, to serve as a basis for starting conversions with various external stakeholders, to suggest possible avenues for joint innovation with start-ups and established players, and to communicate to prospective employees the types of innovation initiatives/projects that could be ongoing at SIX in the years to come.

We understand white papers as a stepping stone in a never-ending journey of better understanding possible futures. We therefore inherently understand it as a work in progress, rather than an end-product, capturing our current views but ready to be updated as new information comes along.

This white paper is the result of a joint effort between SIX and the wider Swiss financial ecosystem. We thank the authors and the many contributors, internal and external, for their hard work and inspiring insights.

We hope you will enjoy the reading, and look forward to constructive discussions.

Daniel Dahinden
Head Innovation & Digital
SIX

Marco Menotti
Head Banking Services
SIX

Dr. Andreas Sprock
Head Innovation Management
SIX

Dr. Alexander Verbeck
Head Cash Ecosystem
SIX

Table of Contents

1 Introduction

"The financial system has experienced innovation boosts before, but this time it is somehow different … [it aims] to improve not only the way payments are made, but also [the] money itself."

– Agustín Carstens, General Manager BIS[1]

What does the future of cash hold? How will cash change? What developments are driving these changes? What does it mean for the cash infrastructure?

We cannot answer questions about the future of cash without considering how money more generally might evolve. **What is considered money, what form it takes, how it is used, and what its infrastructure looks like, all look set to change dramatically in the near future.**

Digital payments are increasingly embedded in customer journeys, from ordering a ride with Uber to booking a vacation on TripAdvisor. Ever more things can launch digital payments as devices and appliances increasingly contain computing chips and connect to the Internet (Internet of Things, IoT).

Banks are required to open interfaces (APIs) to their customer data, enabling third parties to launch digital wallets and payments, without resorting to payment schemes, and challenging the bank's customer relationships.

New digital currencies are being launched or planned every other day (from JP Morgan coin, Walmart's coin, Facebook's Libra, or Bitcoin to name a few) and pave the way toward the use of alternative (nonmonetary) assets for payments.

In return, central banks are considering their own digital currencies by offering public access to central bank accounts.

Cyberattacks are rampant, ever more sophisticated, and increase the risk of large systematic failures and large-scale data losses, threatening to undermine trust in the entire system.

Regionalism and isolationism talks are starting to include the money infrastructure (e.g., payment schemes), driven by rising global tensions and weaponization of economic tools.

It looks as if nothing will look like the past.

1 Agustín Carstens, 2019, Ideen zur Zukunft des Geldes, Frankfurter Allgemeine (14 June 2019), „Das Geldwesen erfährt nicht zum ersten Mal einen Innovationsschub, doch diesmal ist es irgendwie anders … [sie zielt] nicht nur [darauf ab] die Art und Weise, wie Zahlungen getätigt werden, zu verbessern, sondern auch [auf] das Geld an sich." [own translation].

This white paper **presents several possible futures for money, in both its physical and digital form**.[2] The scenarios focus on the future in Switzerland, but certain discussions will take us beyond its borders.

Our goal is to **help strategic decision-makers in setting the strategic direction**. We hope it will help in identifying potential market opportunities, in spotting one of the next big waves,[3] in better understanding new technologies,[4] in getting a sense of the implications of possible technological and societal developments,[5] in creating awareness for implicitly-held assumptions and beliefs underlying current strategic directions,[6] in recognizing strategic risks, in providing a mental framework for making sense of the never-ending feed of news, and/or in the communication of their strategies.

Our findings are synthesized in the form of future scenarios because we view scenarios as an optimal means of communication.[7] Our time horizon is **5-7 years**, as a compromise between fast-changing digital behaviors and solutions, and the longer life cycle of the physical infrastructure like ATMs and bank branches.

When thinking about the future of 'something', it is dangerous to think in terms of today's structures, concepts, and vocabulary because we risk inadvertently biasing our thinking to 'what is'. Instead, ***we should start by defining this something at an abstract level***. More specifically, we believe that we should try to describe this something **in terms of the value it creates (or the 'jobs it is hired to do') at an abstract level.[8]**

It is generally accepted[9] that **Money creates value for people and society in three distinct ways.[10]**

- by serving as a store of value
- by serving as a medium of exchange
- by serving as a unit of account

We furthermore believe that **Money Infrastructure**[11] **has essentially created value for people and society in two distinct ways.[12]**

- by protecting and securing money
- by facilitating exchanges of value

The following pages will first describe our method, summarize the various factors of influence considered, and provide a brief overview of our different scenarios. **The introduction contains all our key statements — the rest of the document allows interested readers to dive deeper into the different topics.**

The remainder of this white paper is then organized as follows. Chapter 2 describes the scenarios we view as most relevant. And Chapter 3 provides some useful definitions.

---

2 Our usage of the concepts of 'money' and 'currency' might differ from everyday usage. For the sake of clarity, we recommend the reader briefly read through our definitions in Chapter 3.

3 Our SIX, 2019, Future of the Securities Value Chain (January 2019), for example, points out that there will likely be an explosion in digital assets, and that existing securities-infrastructure providers (e.g., Exchanges, CCPs, custodians, CSDs) can leverage their capabilities by expanding from traditional financial securities (e.g., equities, bonds, structured products) to digital assets more generally.

4 Our SIX, 2019, Financial Information points out that secure and privacy-preserving data distribution and access systems will allow users to process the data without moving the raw data (even in its encrypted form) from where it is stored — only the results of the processing (e.g., trained model parameters) are distributed.

5 The SFTI, 2019, Future of Financial Institutions discusses in-depth the consequences of increasing (possibly mandated by regulators) interoperability and unbundling on business models and competitive advantage.

6 Our SIX 2019 Future of the Securities Value Chain (January 2019), for example, points out in its second-most likely scenario that 'listing at an Exchange' may cease to be perceived by market participants as an indicator of the quality of the financial product, leading to the disappearance of 'listing'. It suggests that the explosion in initial coin offerings (ICOs) of the mid-2010s may have been driven by a shifting preference of issuers and investors toward non-listed financial products — rather than driven by a preference for ICOs' underlying technology (permissionless distributed ledgers), which tends to be the popular explanation for that development.

7 See Section 'Method' on page 7 for a description of how we arrive at our scenarios.

8 This approach has been referred to as 'first principles design thinking'; see e.g., Brett King, 2018, Bank 4.0: Banking Everywhere, Never at a Bank (Marshall Cavendish: Tarrytown, NY), pages 23-32, noting that this kind of thinking is characteristic of the likes of Carl Benz, Steve Jobs, or Elon Musk.

9 See footnote 180 and the text surrounding it: Money is generally defined as anything jointly fulfilling these three functions.

10 See Chapter 3, and Exhibit 1 on page 8 for a brief discussion of these three aspects.

11 We use 'money infrastructure' to point out its role as a key, not always perceptible, fundament for the functioning of the economy.

12 There undoubtedly exists an even higher level of abstraction that captures financial institutions' value propositions. We, however, believe that our categories strike a nice balance by opening our thinking while providing enough structure to facilitate communication. See Exhibit 2 on page 9 for brief description of these two aspects.

Method

We use a five-step process to identify our scenarios.

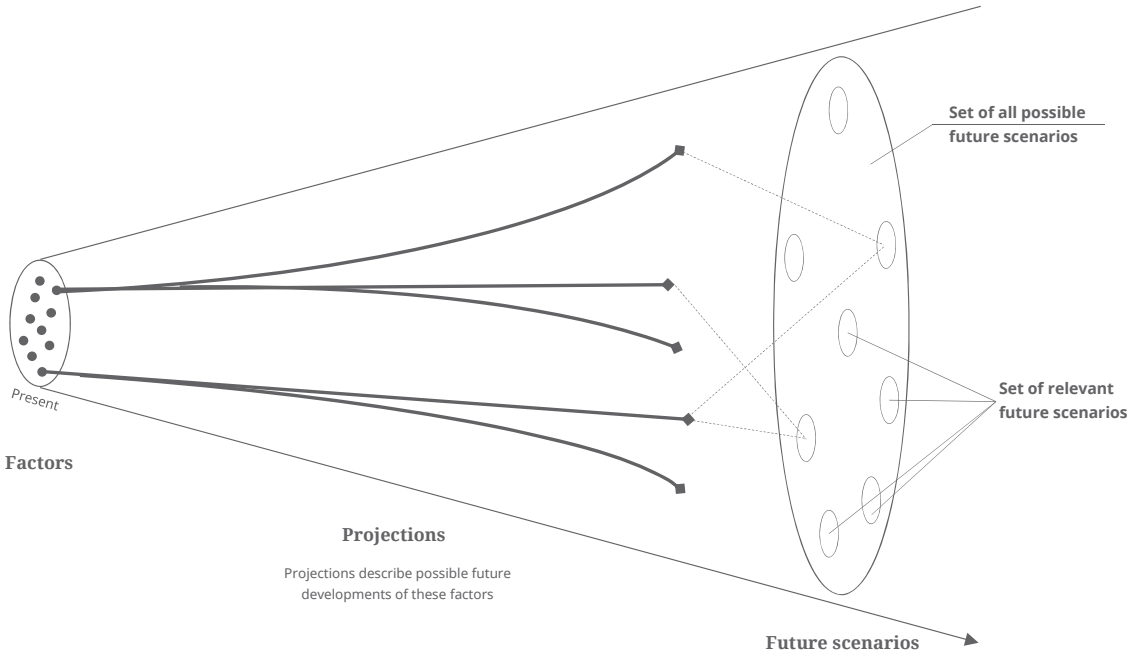
- We start by **abstracting the system under analysis in terms of 'jobs it is hired to do'**. The high-level categories we abstracted to are depicted in Exhibit 2 on page 9.
- We consider a vast array of factors across all STEEP dimensions (social, technological, economic, environmental, political) and identify **possible future developments** (or 'projections') for each of these factors.
- We then assess how both individual and combinations of developments could **impact** the above-mentioned high-level categories. This is both a rational as well as creative exercise.
- It is difficult to work with this unstructured information about the future. We therefore synthesize this information about the foreseeable future variability in the form of **scenarios** by combining internally consistent future developments.
- We finally **challenge** this set of future scenarios from different angles to reduce the likelihood of missing key developments.

Our set of scenarios does **not aim to provide a map of all the foreseeable future variability** — we provide a set of possible future scenarios that we view as most helpful for strategic decision-makers setting the strategic direction for the future.

We strive for a **heterogeneity in the sources of data and information**. A large and diverse number of people were involved throughout this exercise in the form of workshops, brainstorming sessions, interviews, and reviews. We attended conferences, read lots of books, papers, blogs, and watched our fair share of science-fiction movies.

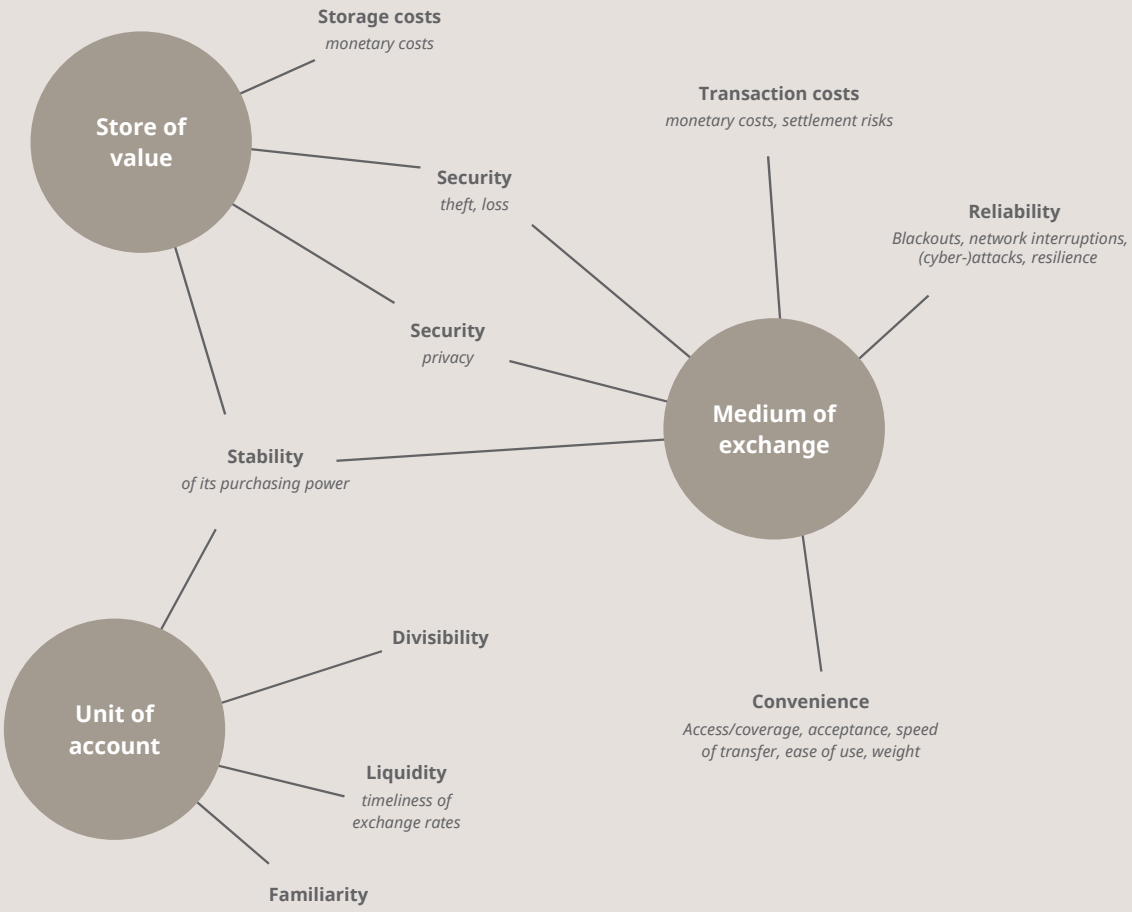
A note of caution. We try to ground all our statements on empirical (qualitative and quantitative) data. But this data does not give definitive answers regarding how likely a development might be, or what its potential impact might be. The data must be interpreted and creatively expanded. Hence, **our statements capture our empirically informed beliefs**. To help each of you make up your own mind, we pay special attention to always explicitly provide our assumptions, reasoning, arguments, and supporting evidence.

If you disagree with our assessments, or if you believe we missed a crucial development/scenario, please contact us. This is a learning journey for us.



Projections are combined to form possible future scenarios, which are then challenged through war gaming, greenfield designing, tipping-point crossing, what-if questioning, 30-year-horizon backward thinking, black-swan scouting

How Money Abstractly Creates Value for Clients and Society, Or: Why Money Is Being Hired by Clients and Society



People consider/weigh (consciously or unconsciously) theses aspects when deciding which asset(s) to use as medium of exchange, store of value, or unit of account. If there is consensus on a given asset to serve all three of these functions, then such an asset is referred to as 'money' (see Chapter 3 for more details).

How Money Infrastructure Abstractly Creates Value for Clients and Society, Or: Why Money Infrastructure Is Being Hired by Clients and Society

Protecting and securing money

It **supports establishing money as a 'store of value' by helping people securely store money**. It **acts as custodian** in both physical and digital realms

- *By offering physical vaults* for people's physical money (e.g., coins, banknotes, gold currency) and for their private keys linked to digital money (cold storage).
- *By offering digital vaults* for people's digital money (e.g., digital bank accounts, digital ledgers).
- *By acting* as gatekeepers to ensure only authorized access to vaults (e.g., pin codes, payment cards, digital identity, biometrics, facial recognition, two-factor authentication, fraud detection).

It **helps people securely move money from A to B** in both physical and digital realms for whatever reason, from relocation to another city, to lending to a friend, to offering it in exchange for goods and services ('means of payment')

- *By guarding the transport of physical money*: From protecting horse carriages in the middle ages (e.g., Knights Templars) to armored trucks transporting physical money between physical vaults, banks, and ATMs.
- *By operating inter-custodian digital ledgers* to allow end-to-end secure digital movement of digital money between digital vaults held at different custodians*

Facilitating exchanges of value

It **facilitates using money as a 'medium of exchange' ('means of payment') by helping people move money from A to B** in both physical and digital realms

- *By securely moving* money from A to B.
- *By issuing bank notes* (e.g., Knights Templar's letters of credit)—which used to contain a right to some commodity currency—to prevent people from having to carry commodity currency (e.g., stones, metal, gold).
- *By offering user interfaces* (UIs) allowing people to access and control their money held in vaults: From branches, to online gateways (e.g., ATMs, websites, mobile apps, AR-device apps, and other digital wallets), to offline and online points of sale (e.g., card terminals, QR codes).
- *By operating digital communication pipes* (e.g., payment schemes) connecting digital UIs with their digital vaults, allowing people to order transfers of digital money from one digital vault to another. This pipe infrastructure amounts to a digital platform because it connects digital UIs to a wide array of custodians, digital vaults, and inter-custodian digital ledgers.

* When the custodians amount to banks, this ledger most notably includes the 'settlement accounts at the central bank' ('Abwicklungskonten/Girokonten bei der Nationalbank'). It also includes the 'nostro accounts at correspondent banks'.

Factors: Catalysts, Drivers, Developments, Trends

The table below depicts some of the factors that were considered in the development of our future scenarios. Factors we consider having the greatest impact are marked in boldface.

Social / Cultural	Technological	Economic	Environmental	Political[13]
24/7 availability	**Advanced analytics**	**Borderless industries**	Ambient-energy harvesting	Anti-competition concerns
Convenience	**Artificial intelligence**	**Crowd sourcing**	Decentralized energy production / smart grid	**Anti-globalization / Protectionism**
Crowd collaboration	**Automation**	**Digital tokenization**	Global warming	Big-tech criticism ('tech-lash')
Customization/ Individualization	**Cyber-security**	Diffusion of knowledge and intellectual property	Increasing environmental pollution	Challenge of public finances
Demographics (aging population)	Frictionless Business	**Digital assets**	Post-oil electricity	**Fear of companies becoming too powerful**
Digital natives	**Human-machine interfaces**	**Digital data**	Renewable energy	**Data sovereignty / control**
Digital User Interfaces (UIs)	Increasing power of information	**Digital marketplaces**	Shortage of raw material	Digital warfare
Do-it-yourself mentality	**Internet of Things (IoT)**	**Disintermediation**		Global power struggles / redistribution
Entrepreneurship	Internetization	E-business		Global stability
Voice-based human machine interfaces (HMIs)	**Knowledge systems**	Eco-capitalism		**Government trust**
Instantaneity	**Machine learning**	Global economic growth		**National-security concerns**
Privacy	Parallelization	Growing education markets		**Openness**
Security	**Privacy-preserving systems**	**Growing global middle class**		Relative loss in power of the United States
Sustainability	(Smart) Chatbots	Increasing intensity of competition		**Surveillance**
Mobility	Quantum computing	**Increasing speed of change**		**Weaponization of economic tools**
Omni channel	Quantum-resistant encryption	Interoperability / Application programming interfaces (APIs)		
One-stop shops	**Virtualization and dematerialization**	Management innovations		
Polarization of wealth	Self-powering chips	**New economic powers**		
Social media	**Standardization**	**Platformification**		
Social sharing		Productivity growth		
		Strong economic blocs		

13 Includes legal and regulatory factors and international relations.

Summary of the Scenarios

We have identified **seven future scenarios** that we think will be of interest to strategic decision-makers in the money infrastructure and service space. Besides a most likely scenario, we have identified several alternative scenarios that we believe could have a substantial impact on the money infrastructure and/or may necessitate considerable adaptations in decision-makers' mental frameworks.

At the risk of repeating ourselves: Our thinking revolved around how the functions money is serving ('jobs it is hired to do') might change.[14] And then we considered how the functions that the money infrastructure is serving ('jobs it is hired to do') might change.[15]

This section briefly summarizes the key points captured by these scenarios. All scenarios are divided/described in two parts: a **context part**, which describes how the broader world looks, and a **money infrastructure part**, which describes how the money infrastructure looks. Our most likely scenario is described in significantly more detail than the alternative scenarios because it captures a multiplicity of concurrent possible future developments — alternative scenarios generally capture only one possible development, making them easier to grasp. Although we strive to make each alternative scenario stand by itself, we recommend first reading the most likely scenario.

Most Likely Scenario: Digital Rules — *but Cash Persists in a Fragmented World*

While we describe the most important facts in this summary, we prepared a **human-centric description** *of this scenario on page 20 to illustrate the impact on everyday life.*

Context: **Digital payments continue to displace cash as a 'medium of exchange'.** At the same time, **cash continues to be perceived and widely used as a 'store of value'.** Overall, **cash holdings fall 40-60%**, mainly driven by a 40-70% decline in cash being used as means of payment.

Digital payments have substantially increased in convenience compared to cash as digital user interfaces' presence expanded into ever more human activities — what started with mobile Internet and smartphones, continued with voice interfaces and augmented reality. Digital user interfaces naturally belong to almost every human activity. **Digital payments are seamlessly embedded in the digital services (e.g., apps, websites, AR, chats) running on digital UIs**, making them more convenient than cash in all contexts marked by a significant digital user interface (UI) presence. Furthermore, **digital payments can automatically and seamlessly be launched by the rapidly growing number of Internet-connected devices (Internet of Things, IoT)**, further contributing to making digital payments much more convenient than cash.

Expectations regarding instant interactions in a digital world led to **instantaneous settlement** of digital payments.

Banks (are required to) open interfaces (APIs) to their digital vaults and customer data, allowing third parties to seamlessly connect their digital wallets, as well. Banks expand into services **'beyond banking'** to counter falling margins in their traditional businesses and to fight for the ownership of customer relationships.

Payment cards have disappeared as authenticators. Physical debit/credit cards have disappeared in payments, replaced by digital wallets directly embedded in digital UIs (i.e., apps) and/or installed on Internet-connected devices (e.g., mobile phone). Although payment

14 See Chapter 3, and Exhibit 1 on page 8.

15 See Exhibit 2 on page 9.

cards may continue to work in the background, stored in the digital wallets as authenticators, **general-purpose digital IDs have replaced payment cards** there as well.

People have reduced their holdings of digital money by investing an increasing share of their capital instead of letting it lay idle in bank accounts. **Nonmonetary digital assets are thus increasingly replacing digital money as a digital 'store of value'**. Finally, an increasing number of people regularly **pays with nonmonetary digital assets**.

Cash Infrastructure: The cash infrastructure had to **substantially reduce operational costs** while continuing to ensure geographic coverage. The lower density in rural areas required a more efficient cash infrastructure in order to continue operating viably without raising prices to a possibly discriminatory level. Additionally, investors continued to demand that banks increase operational efficiency (including cost reductions), and cash infrastructure was an area of focus.

The cash infrastructure is being operated centrally to sufficiently increase its efficiency, but pressure to reduce costs remains. **The number of ATMs falls 30-40%**, in line with an elimination of cash services in bank branches. Convenience and cost pressure have led to **crowd-sourced (P2P, P2M) cash infrastructures becoming an essential part** of the cash infrastructure. **Smart-banknote infrastructures** have also seen the the light. **Both infrastructures may individually disrupt** traditional cash infrastructures by promising the same or better coverage at lower costs. **In rural areas, crowd-sourced cash infrastructure has led to an almost-circular cash economy**.

Digital-Money Infrastructure: The digital money infrastructure **settles instantly**. It is also **fully programmable**, allowing anyone to write and run programs that directly link/reference digital money. Since digital currencies/money is simply a special case of **digital assets, a digital-assets ledger infrastructure may disrupt** traditional digital money infrastructures.

In response to increasing concerns over reliance and dependence on money infrastructure operated by (foreign) global players, **national/regional money infrastructures** (e.g., national payment schemes) have seen the light. They are interoperable with third-party global infrastructures, but can be run in complete isolation.

Incumbent payment schemes face increasing competition and substitution risks as the number of alternative communication pipes, enabling customers to send payment data to their bank, rises. **Payment-API aggregators may become the new payment schemes**.

Digital Infrastructure: Expectations for the infrastructure in terms of security and privacy have substantially increased. **People are highly aware of the potential costs of trusting too easily with their data** as they have seen their data being lost, made public, sold in non-anonymized form, lying around unencrypted for employees to peruse, or used for blackmailing.

At the same time, **cyber-threats have continued to increase in sophistication**. Secure digital communication pipes may necessitate a fundamental rebuild of the underlying Internet architecture/protocol.

Alternative Scenario: *Digital Currency Is the New Cash*
Context: **Cash holdings drop 80%**. Digital means have not only replaced cash as the dominant 'means of payment', **digital money/assets have also largely displaced cash as a safe 'store of value'**.

People may become substantially less concerned over the security, privacy, and bankruptcy risks relating to digital currency.

Government may discourage people from holding cash: They may require businesses to set higher prices for goods/services paid with cash while at the same time reducing how much digital currency one unit of cash buys.

Money Infrastructure: The drastic fall in cash usage **puts additional pressure on the cash infrastructure to significantly lower costs while still providing geographic coverage (to significantly increase efficiency).**

Alternative Scenario: *Rise of the Central Bank Digital Currency*
Context: **Anyone can have an account at the central bank**. Put differently, anyone can hold digital currency issued by the central bank — referred to as 'central bank digital currency' (CBDC). **People can choose where to hold their digital currency**, at an account with the CB and/or a commercial bank.

The usage of cash may decline as people holding digital currencies no longer have to bear the bankruptcy risks of commercial banks.

Money Infrastructure: CBs may operate their own digital ledger (CB-account infrastructure) and/or rely on digital ledgers by third parties.

Alternative Scenario: *Central Banks Are Dead, Long Live Central Banks!*

Context: **New centrally-issued currencies are the new money**. New currencies and issuers replace sovereign currencies respectively states' central banks (e.g., CHF and SNB, EURO and ECB). **Nonsovereign currencies have become dominant**.

Money Infrastructure: **New players/issuers may (partly) rely on existing money infrastructures if they are modern enough**: These nonsovereign issuers may look to build upon existing infrastructures because they may benefit from the incumbent's trustworthy and reliable reputation, because they can scale more rapidly (in particular with physical infrastructure), and/or because they benefit from economies of scale.

Alternative Scenario: *A Cashless World Is Born*

Context: **Cash disappears completely**. The cashless society is finally born. The most likely path to such a scenario is through **government enforcement** because otherwise everyone would need to overcome their concerns over the security, privacy, (cyberattack and network-interruption) resilience, and bankruptcy risks relating to digital currency; and to no longer exhibit a preference for cash in any circumstance.

Money Infrastructure: **A 'digital cash' infrastructure may take the place of the 'physical cash' infrastructure.**

The physical cash infrastructure may, however, not be dismantled entirely: Some of it may be leveraged to increase security and control over digital currencies. The ATMs may be used for offline two-factor authentication by distributing uniquely-identifiable tangible pieces of paper that are necessary to control some digital currencies. The physical banknotes may be used as uniquely-identifiable pieces of paper. And the physical vaults may be used for cold storage of uniquely-identifiable pieces of paper and of tangible non-digital private keys more generally.

Alternative Scenario: *Moneyless Begins*

Context: **There is no such thing as 'money' anymore**. No asset in the economy — not even currencies — fulfills the three conditions for it to be classified as 'money'.

Money Infrastructure: **The money infrastructures continue to be relevant**. Although money per se does not exist anymore, people still hold the physical and digital assets that amounted to money, and people still exchange those assets. However, **the demand for and exchanges in these hitherto-monetary assets falls substantially**.

Alternative Scenario: *It's a Bitcoin World*

Context: **Decentralized digital currencies have become dominant**: Crypto-currencies (e.g., Bitcoin, Ether) have **replaced central-bank-issued currencies** as the dominant forms of money.

Money Infrastructure: Permissionless distributed ledgers amount to the underlying infrastructure for securely storing and transferring digital money. Third-party digital UIs (e.g., digital wallets) and payment systems may be built and run on top of these ledgers — as **DApps**. Even if people do not trust a (centralized) entity to issue it, **cash may continue to exist if some real-world objects are uniquely identifiable**.

Inputs for Strategy

This Section presents some fundamental changes reflected in our scenarios, and indicates some possible moves to cope with these changes.

Changes in the Fundamentals of How the Business Works

Digital payments continue to displace cash as a 'medium of exchange'. Usage of cash for payment falls by 40-70%. Digital payments increase in convenience compared to cash as digital UIs' presence expands into ever more human activities — what started with mobile Internet and smartphones, continues with voice interfaces and augmented reality. Digital payments are embedded in Internet-connected devices/things, which can automatically launch payment orders.

Digital money/assets may even displace cash as a safe 'store of value'. Cash may no longer be viewed as a safer store of value than digital money/assets. People may become much less concerned with the security (theft, bankruptcy risk of banks) or privacy (data breaches) of digital stores of value.

Banks are opening interfaces (APIs) to their data. Governments have mandated banks to open interfaces to their digital vaults and customers data ('open banking regulations'). These interfaces enable third parties to launch digital payments without resort to payment schemes. These interfaces also enable third parties to put their digital wallets before the banks, challenging the banks' customer relationship.

Payment cards are replaced as authenticators by digital IDs. Physical debit/credit cards disappear. General-purpose digital IDs replace payment cards even as authenticators in digital wallets.

People regularly pay with nonmonetary digital assets. People have been paying with their data for some time, and are now regularly paying with other nonmonetary digital assets. These transactions may, however, not amount to barter: An intermediary may take on the nonmonetary digital asset and pay the seller in 'digital money'.

People expect instantaneity and zero transaction fees in the digital sphere. People do not see a difference between transferring texts, pictures, videos and transferring money over the Internet, both are just 0s and 1s. Importantly, instantaneity is also expected in cases of payments with nonmonetary digital assets.

The cash infrastructure must be operated at significantly lower costs while still providing full geographic coverage. The lower density in rural areas requires a more efficient cash infrastructure to continue operating viably without raising prices to a possibly discriminatory level. Investors have also continued to demand that banks increase operational efficiency (including cost reductions), from which the cash infrastructure has not been immune. If people use cash much less frequently, too high prices may become a focal point to assess their banks' innovative capacity, competence, and concern for their clients (trustworthiness). If banks do not reduce costs/prices, they may lose the customer relationship (loss of brand recognition) to digital UIs provided by companies perceived as innovative. They may also lose business (e.g., in advisory) to players perceived as more competent and trustworthy.

Crowd-based solution may disrupt the cash infrastructure. A crowd-sourced (P2P, P2M) cash infrastructure may not only run more efficiently (lower cost for equivalent coverage), it may also offer better coverage.

Smart banknotes may disrupt traditional banknotes because they have all the benefits of traditional cash and some more. Smart banknotes may be as immune to blackouts and network/connectivity interruptions as traditional cash. Smart banknotes may be as privacy (anonymity) preserving as traditional cash. Smart banknotes

are more secure than traditional cash because they can instantly be deactivated in dangerous situations.
Digital-assets ledger infrastructures may disrupt traditional digital money infrastructure. Digital money is just a special type of 'digital asset'. Issuers of digital money may shift to modern digital-assets infrastructure that benefit from a broad and innovative ecosystem and exhibit larger economies of scale.

Digital money infrastructure is fully programmable. Digital money infrastructure allows code (aka 'smart contracts') to be written directly into the ledger and to be directly executed from there.

Trustworthiness in terms of security and privacy is likely to be a source of competitive advantage. People are highly aware of the potential costs of trusting too easily with their data. People highly value security and privacy regarding their personal data. People are highly aware that cyber-threats have continued to increase in sophistication.

Possible Moves

Consider centrally operating the national cash infrastructure as a utility. The cash infrastructure must become significantly more efficient. The physical ATMs and cash infrastructure in branches, the software, and the transport of cash to-and-from cash points all benefit from economies of scale.

Consider exploring the potential of crowd-sourced (P2P, P2M) cash infrastructures. Such a cash infrastructure may be necessary to sufficiently increase the efficiency of the cash infrastructure. Furthermore, such a cash infrastructure may disrupt legacy cash infrastructures by not only reducing costs, but also increasing convenience/coverage.

Consider exploring the potential of smart banknotes. A smart banknote may be necessary to sufficiently increase the efficiency of the cash infrastructure. Furthermore, a smart banknote may disrupt traditional cash, and therewith traditional cash infrastructure.

Consider building the infrastructure enabling bank-account portability. People can seamlessly switch between digital-vault providers and digital-wallet providers because bank accounts are fully portable.

Consider building the API infrastructure/platform necessary for API banking. API Banking is widespread: Banks are embedding their services into third-party applications (embedded finance), are integrating third-party solutions into their own services/UIs, and are developing new businesses on top of APIs.

Consider setting up a national payment scheme. Governments are pushing for independent national/regional money infrastructure (e.g., national cash or payment schemes) that is interoperable with third-party global infrastructures, but can be run completely independent of other schemes or infrastructure.

Consider building, partnering, or operating a digital-assets ledger infrastructure. Digital-assets ledger infrastructures may disrupt traditional digital money infrastructure. Digital assets that are issued on these ledgers are sometimes referred to as 'tokenized assets' or 'tokens'. Consider exploring the different types of ledgers, from central ledgers, to permissioned distributed ledgers, and permissionless distributed ledgers. The latter may help prepare for a 'crypto-currency' world, where everything runs on permissionless distributed ledgers.

Consider exploring next generation Internet infrastructure for secure financial data communication. Cyber-risks continue to increase, and data security and privacy is likely to amount to a competitive advantage. Digital communication pipes running through the open Internet are particularly at risk. Digital UIs from ATMs, to mobile apps (e.g., digital wallets), and payment termi-

nals, all require sending data through the open Internet. Secure data communication may need a fundamental rebuild of the underlying Internet architecture/protocol.

Consider exploring payment infrastructures that are resilient to blackouts and network interruptions. The risk of blackout and network-interruption events has increased substantially as the sophistication of cyberattacks continues to increase. Blackouts and network interruptions may not only cripple digital payments, they may also adversely affect the cash infrastructure (e.g., taking out ATMs). Note also that such resilience is a prerequisite for a cashless economy.

Consider exploring resilient digital currencies that continue working during blackouts, network interruptions, and loss of digital ledger. The risk of such events has increased substantially. Resilient digital currencies might use P2P connectivity (e.g., Bluetooth, USB cables) to avoid reliance on Internet connectivity. Ambient-energy harvesting may prevent devices from having to rely on third-party energy production.

Consider supporting nonsovereign entities wanting to issue their own currencies. Nonsovereign currencies may replace sovereign currencies to become the dominant form of money, with their issuers replacing states' central banks. These nonsovereign issuers may look to build upon existing infrastructures because they may benefit from the incumbent's trustworthy and reliable reputation, because they can scale more rapidly, and/or because they benefit from economies of scale. A prerequisite for such collaboration is that the infrastructure is state of the art. Such partnership could help incumbents prevent disruption of their infrastructure if sovereign currencies were to be replaced as the dominant form of money.

2 Relevant Future Scenarios

Digital Rules — But Cash Persists in a Fragmented World

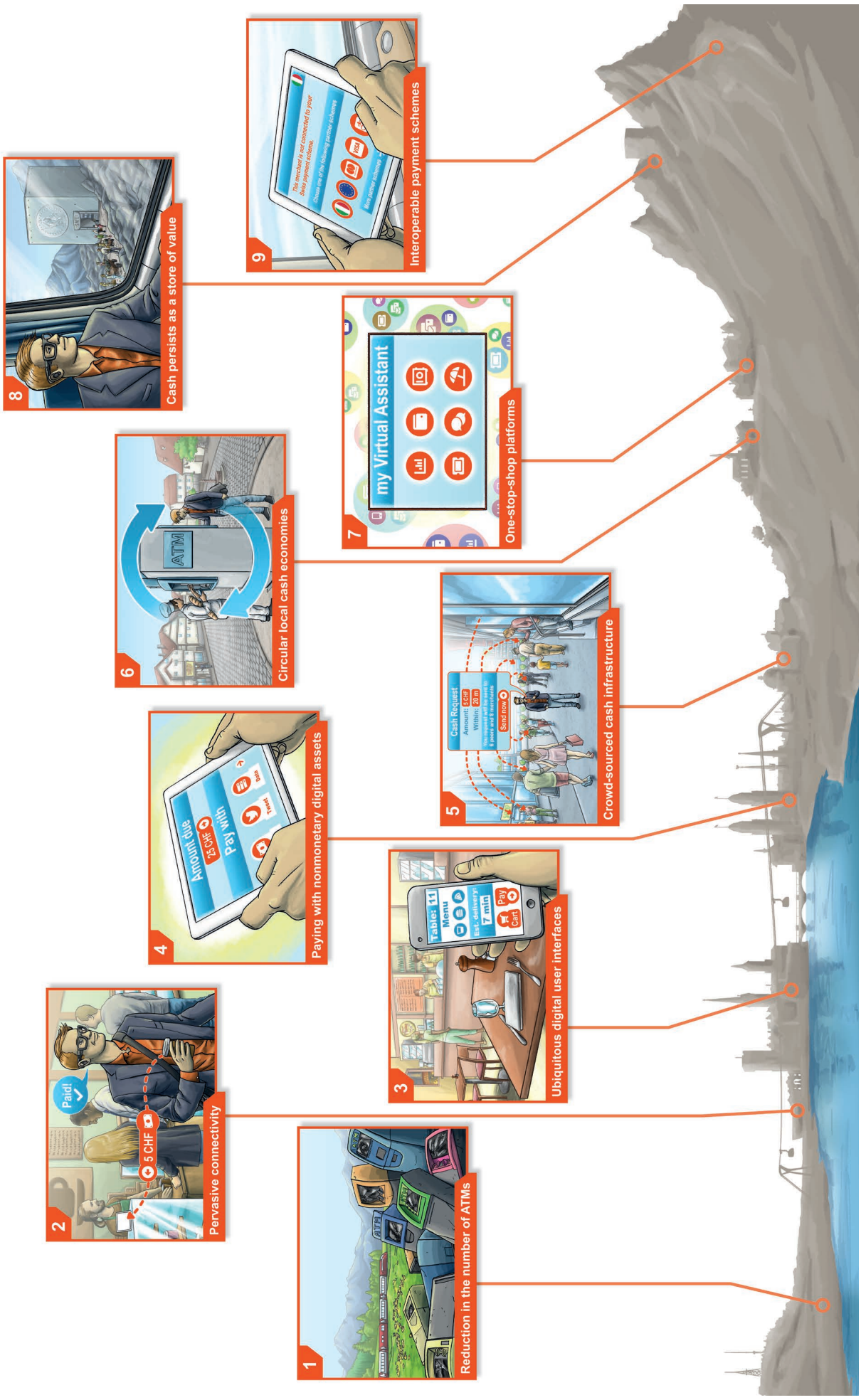
Likelihood of occurrence: Most likely

Abstract: People demand instantaneity everywhere. Digital user interfaces are ubiquitous, present in almost every human activity. People are highly aware of the potential costs of trusting too easily with their data. Banks (are required to) open interfaces (APIs) to their digital vaults and customer data, allowing third parties to seamlessly connect their digital apps (e.g., digital wallets). Banks expand into services 'beyond banking' to counter falling margins in their traditional businesses and threatened ownership over customer interfaces.

Cash continues to be perceived as a very safe 'store of value', but continues to fall in usage as a 'means of payment'. Smart banknotes, which can be activated/deactivated remotely, mark the next evolution of cash, but cannot stop the reduction of cash as a means of exchange. Cash holdings fall 40-60%, mainly driven by a fall in usage of cash as a means of payment by 40-70%. Digital payments continue to displace cash. Digital payments settle instantaneously, are increasingly convenient compared to cash as digital UIs spread to ever more human activities, and are seamlessly embedded in Internet-connected devices/things that can automatically launch payment orders. Payment cards have slowly disappeared, displaced by digital wallets and general-purpose digital IDs as authenticators.

The cash infrastructure must operate at significantly lowers costs while continuing to provide full geographic coverage. It is centrally operated to yield enough efficiency gains. The number of ATMs falls 30-40% in line with the elimination of cash services in bank branches. Convenience and cost pressure have led to crowd-sourced (P2P, P2M) cash infrastructures becoming an essential part of the cash infrastructure. Smart-banknote infrastructures also see the light. Both infrastructures may individually disrupt traditional cash infrastructures by promising the same or better coverage at lower costs. The digital money infrastructure allows instant settlement and is fully programmable. Since digital currency/money is simply a special case of digital assets, the digital money infrastructure may be disrupted by general-purpose digital-assets ledger infrastructure. National/regional money infrastructures (e.g., national payment schemes) see the light. Such infrastructures are interoperable with third-party global infrastructures, but can be run in complete isolation. Cyber-threats continue to increase in sophistication and secure data communication may require a rebuild of the underlying Internet architecture/protocol.

Early-detection signals: growing instantaneity expectations, spread of open banking regulations, rising competition in banking services, falling technical switching costs between (financial) service providers, explosion in investable assets, democratization of investment space, persistent perception of cash as the safest store of value, increasing convenience of digital payments relative to cash, growing adoption of digital interfaces in ever more customer journeys, growing concerns over weaponization of economic tools, increasing sophistication of cyberattacks.


1
Reduction in the number of ATMs
2
Paid!
5 CHF
Pervasive connectivity
3
Table: 11
Menu
Est. delivery:
7 min
Pay
Cart
Ubiquitous digital user interfaces
4
Amount due
25 CHF
Pay with
Paying with nonmonetary digital assets
5
Cash Request
Amount: 5 CHF
Within: 20 m
Send now
Crowd-sourced cash infrastructure
6
ATM
Circular local cash economies
7
my Virtual Assistant
One-stop-shop platforms
8
Cash persists as a store of value
9
Interoperable payment schemes

The Human-Centric Story

We are in the year 2025. At first glance, the life of Felix Muster has hardly changed over the last few years: At half past six in the morning his smartphone wakes him. A few minutes later, Felix contemplates in the bathroom mirror the latest news alongside the most important data on his income and expenditures, while the toothbrush dutifully analyzes his health. The data is then shared with the medication robot in the kitchen, which dispenses the vitamins and additional tablets for the day.

At 7:33 a.m., his commuter train leaves from his suburban community on Lake Zurich to Zurich main station. From his train window, he sees an ATM cemetery, where some of the many out-of-service ATMs are temporarily stored before being dismantled **(reduction in the number of ATMs)**. At the main station, his favorite coffee is already waiting in the coffee shop next door — he preordered it while still on the train via his digital assistant, which perfectly timed the order to ensure it was just the right temperature. While walking out of the coffee shop, Felix gets the notification from his digital assistant that his bank account has been charged with a take-away espresso **(pervasive connectivity)**.

Only when the weather is fine and he does not meet any colleagues in the tram does Felix use the E-scooters, which have become surprisingly robust in recent years, for the last 700 hundred meters. Today, a colleague he has not seen in a while is already waiting at the tram stop. Tram line 4 then takes him to his employer's headquarters.

His second morning coffee, from the machine on the first floor, still tastes too bitter, but as every morning, he proclaims "Most important is that the coffee wakes you up!" The coffee is also billed directly in the background and deducted from his salary. While slurping his wake-up coffee, he realizes that his digital assistant automatically adjusted the alarm clock in his smartphone to allow him 17mins additional sleep because his first meeting was cancelled late last night when he was already sleeping.
Later in the morning, Felix meets his best friend for lunch in a pizzeria. At the front door, Felix asks his digital assistant for their table, which they find easily thanks to the exact guidance of his digital assistant. They both consult the menu on Felix's smartphone. Both decide on a pizza, which they order via Felix's digital assistant **(ubiquitous digital UIs)**.

After yet another coffee, Felix offers to pay for both and asks his assistant to pay the bill. He is informed that he can pay part of it with the data they both produced in the restaurant, and that he can get an additional discount if he Tweets about the restaurant. Felix tells his digital assistant to do both and mention that the pizza was fantastic **(nonmonetary assets as means of payment)**.

Before leaving, he wants to tip the pizzaiolo in cash. Old habits die hard. Felix looks into his wallet and notices that he has no cash. He asks his digital assistant to query people and merchants nearby for 5CHF in cash **(crowdsourced cash infrastructure)**. A young lady walks up to him, holding 5CHF in one hand, and her smartphone with a QR code in the other. Felix scans the code and asks his digital assistant to transfer 5CHF of digital money to that account. Before he can finish his sentence, the young lady receives a message that the amount has been transferred to her account — digital payments have really become instantaneous.

While handing the 10CHF banknote to the pizzaiolo, Felix sees a curious chip embedded in the banknote. His colleague tells him that he has heard about these experimental smart banknotes but had never seen one with his own eyes before.

Later that day, Felix is back in his village and reminded that he has to buy some bread, and that he should hurry because the shop is about to close. He arrives, sweaty, but just in time as the baker was about to close the door. Happy and hungry, Felix walks away with the bread under his arm, and observes the baker walking away with a wallet full of cash toward the village ATM — there used to be many more. Felix remembers an article talking about merchants recharging local ATMs, thus producing an almost self-sufficient local cash economy: Locals take out cash at the local ATM, spend it at local merchants, who then recharge the local ATM **(circular local cash economies)**. It is true, he cannot remember when he last saw an armored truck bringing cash to the local ATM.

At home, it's 6:44 p.m., and Felix still finds the time to discuss the summer holiday plans with his partner Sonja and their two children. His digital assistant connects to a one-stop-shop digital platform, integrating all relevant unbundled services by different financial services providers, and synthesizes all relevant information about account balances and savings **(one-stop-shop platforms)**.

His digital assistant has been building up the budget since last Christmas and optimized the monetization of their assets: Their bicycles and ski equipment were given to the community-wide rental pool, their apartment was rented during their ski holidays, and their roof was rented to an urban gardening project. The biggest problem with the family holiday discussion, however, is not the question of whether to go to the mountains like last year or to the sea like in years before. But how to get there? Holidays in virtual worlds offering complete immersion have not (yet) established themselves, but the technology is already in use to help travelers select a destination.

The group decides it will once again enjoy two weeks in the mountains in northern Italy. The next morning, they all hop into the green-electricity-powered train heading to Italy. His daughter points her finger and asks what those weird bunker-like buildings are. Felix does not know either. Lucky them, his digital assistant does: They are physical vaults built under the Alps for people to safekeep their valuables, including cash. Cash is still viewed as a safe store of value; the digital assistant adds **(cash persists as a store of value)**.

Before even having both feet on the ground in Northern Italy, his older daughter already runs towards a gelato stand. She has been talking about gelato for at least the last hour. A visit to Italy without eating gelato is indeed unimaginable. Felix joins her at the stand and knows he will have no problem paying with his Swiss mobile wallet. His digital assistant, however, informs him that the gelato vendor is not connected to his default Swiss payment scheme. The digital assistant then asks him to choose between partner payment schemes that are connected to the merchant and interoperable with his Swiss payment scheme **(interoperable payment schemes)**. Only Felix's favorite ice cream flavors have survived through the years: vanilla, strawberry and chocolate. Not everything has changed in Felix' life...

I. Context

Ia. General Developments[16]

Increasing Demand for Instantaneity

People's expectations in terms of instantaneity have continued to increase, **driven by their user experiences with big tech companies**, where messages and posts can be instantaneously shared with people around the globe. Instantaneity has found its way into every aspect of life ('instant economy'). Physical packages or the hot 10 o'clock coffee are no longer only delivered at fixed addresses, but can be sent to our current exact location for us to instantly enjoy.[17]

Ubiquitous Digital User interfaces (UIs)[18]

The usage of digital UIs has spread to ever more aspects of one's life: Digital user interfaces (UIs) are ubiquitous, naturally belonging to the fabric of almost every activity we undertake, from ride hailing (think Uber or Lyft), to food delivery (Uber Eats or Eat.ch), to order food inside restaurants (e.g., McDonald's, Muume), to shopping (e.g., Alibaba, Amazon, eBay, Flipkart),[19] to movie renting (e.g., Netflix), to home renting and buying (e.g., AirBnB), to trip planning (e.g., TripAdvisor), to education (e.g., Udemy). The advent of augmented reality and voice interfaces has seen digital UIs creep into ever more of our activities. Most customer journeys are no longer imaginable without a digital UI, such that we only realize their presence in their absence, when network interruptions prevent us from using our beloved digital UIs.

Broad Awareness of Security and Privacy Risks[20]

Most people have experienced firsthand the costs of trusting service providers with their data too easily.

- Their data was treated with little care, lying around unprotected.[21]
- Their data was accessible to employees.[22]
- Their data was sold without them knowing, at times in non-anonymized form.[23]
- Their data was used to manipulate their choices and actions.[24]
- Their data was stolen,[25] lost,[26] and/or used for blackmailing.[27]

---

16 We only address the points we view as directly relevant for the scope of this paper. For a broader description of this most likely future scenario, we refer the reader to the most probable scenario in SFTI, 2019, Future of Financial Institutions.

17 GPS-based location allows delivering packages where you are. If additional information about your location is provided, algorithms compute how you can be optimally intercepted on your path there. (Package delivery will behave like missile defense systems that calculate how and where to intercept enemy projectiles.)

18 This process was captured by "Software is eating the world" (Marc Andreessen, 2011, Why Software is Eating the World, The Wall Street Journal, 20 August 2011).

19 Which includes physical shops being replaced by digital experiences.

20 For more details, see the discussion on 'Increased importance of trustworthiness' in the most likely scenario of SFTI, 2019, Future of Financial Institutions.

21 Uber employees could easily spy on the movements of politicians, celebrities, friends, and ex-boyfriends/girlfriends (The Guardian, 2016, Uber employees 'spied on ex-partners, politicians and Beyoncé, 13 December 2016). Google accidentally stored passwords from some corporate G suite users in plain text since 2005; see e.g., Wired, 2019, Google Has Stored Some Passwords in Plaintext Since 2005 (21 May 2019).

22 Thousands of Amazon employees around the world are listening to voice recordings captured by their Echo speakers to improve their AI-based user interfaces' speech recognition (i.e., to improve 'Alexa'). Although customers can opt out, they are not explicitly told that humans might be listening in. See e.g., Bloomberg, 2019, Amazon Workers Are Listening to What You Tell Alexa (11 April 2019).

23 Mobile carriers and location-based apps (e.g., weather apps) have sold their data to third parties – even after they swore they would stop (Wired, 2019, Carriers Swore They'd Stop Stelling Location Data. Will They Ever?, 9 January 2019).

24 Our digital data allowed creating detailed behavioral/psychological profiles, which then allowed tailoring messages to leverage our deepest fears, prejudices, and beliefs. Besides influencing our shopping decisions, this data was arguably also used to influence our votes in political elections.

25 To name just a few: Facebook suffered a data breach of almost 50 million user accounts in 2018 (Wired, 2018, Everything We Know About Facebook's Massive Security Breach, 28 September 2018); Marriott had 500 million guest records stolen, including the guest's name, postal address, phone number, date of birth, gender, email address, passport number (Financial Times, 2018, Marriott breach potentially exposed data of 500m guests, 30 November 2018).
The year 2019 marked a watershed moment for digital data privacy and security. It was the year the iPhone was hacked as the result of a simple visit to a website. Hackers could monitor live GPS data, grab pictures, turn on microphones, grab passwords and access tokens, and read end-to-end encrypted communication (since the data is decrypted on the sender's and receiver's devices). This changes everything: Conventional wisdom was that only high-value targets (e.g., journalists, lawyers, activities) were really at risk because of the high costs of such a hack (1-2mUSD). Now, it was clear that anyone was at risk even on what was considered the safest device. See e.g., Wired, 2019, Mysterious iOS Attack Changes Everything We Know About iPhone Hacking (30 August 2019).

26 Facebook lost the data from over 50 million of its users. Guardian, 2018, Revealed: 50 million Facebook profiles harvested for Cambridge Analytica in major data breach (17 March 2018).

27 Even the world's wealthiest person, Jeff Bezos, had digital private communication and intimate photos stolen and used for blackmailing (Wired, 2019, Jeff Bezos Goes Hard Against The National Enquirer, 7 February 2019).

People have come to **greatly value security and privacy regarding their personal data**. Convenience and immediate rewards continue to be valued, but convenience and other short-term **benefits no longer always win in the digital sphere.**[28]

Service providers with a strong reputation of **trustworthiness in terms of security and privacy may amount to a source of competitive advantage** as customers may (up to a certain point) accept lower agility, convenience, and innovation in exchange for better data security and privacy. This may especially be the case in the financial services space where the data contains enormous private information.

API Banking Is the New Normal

In 2018, a new regulation (PSD2) came into force in the EU, requiring banks to provide APIs for third parties to access their clients' data and to trigger payment orders. In order to keep up with Europe (SEPA, EEA), **Switzerland's regulators also moved to require opening the banks' interfaces**.

Although these open-banking regulations were at the origin of banks' opening, **banks have since experienced a paradigm shift from their classic 'closed' mindset to a more 'open' approach**. Banks saw the business potential of APIs in other industries: eBay generates 60%, Salesforce 50%, and Expedia 90% of their revenues through their APIs.[29] Third parties can, for example, integrate/embed eBay's services and data directly into their own applications. Successful companies have seen APIs not only as a technical tool, but as a strategic source of value in the digital economy. **Banks now generate one-third of their revenues through APIs**. Customers gravitate to financial institutions that allow their services/solutions to be embedded in customers' favorite digital applications.

Digital Wallet Wars

Anyone can set up a digital wallet.[30] Open banking regulations and API Banking more generally enable companies to readily offer digital wallets without having themselves to acquire the necessary licenses to operate a digital vault: The bank account, for instance, is offered in partnership with a licensed bank — the bank has the digital assets in custody and can be accessed/controlled via the digital wallet.

Digital wallets offer aggregation across digital vaults. Digital wallets provide overview and control over one's digital assets across different digital vaults (e.g., across different bank accounts). The customer can freely decide which digital vaults to connect to a digital wallet.

The market of digital-wallet providers has experienced consolidation, but **a strong heterogeneity in the usage of digital wallets and custodians persists**. Different people hold, access, and control their digital assets (incl. sovereign currencies) in widely different ways. Some hold them in a single digital vault (e.g., at a single bank), others spread them across different digital-vault providers.[31] Some use different digital wallets to access and control different digital assets, others use aggregation wallets to have a one-stop overview over all their digital assets. Some use the custodian's own digital wallet, others prefer the UI of a third-party digital wallet. And still others use a one-stop shop app offering access to an all-inclusive offering of financial services (e.g., digital wallet) and non-financial services — a 'super app' à la WeChat in China.

Many different candidates vie to become a widely-adopted digital wallet. We only name a few hereinafter, but they give a sense of the diversity that already existed in the 2010s:

- In Mexico, the ride hailing company Uber offers its drivers a digital wallet in partnership with the Bank BBVA because many of its drivers lacked a bank account.[32] Uber follows the same strategy in the USA, targeting mostly foreigners without access to a bank account.

---

28 It has been argued that 'convenience' was the main driver of human decision-making in the digital sphere in the early twenty-first century: "Convenience is the most underestimated and least understood force in the world today ... convenience" (Tim Wu, 2018, The Tyranny of Convenience, New York times, 16 February 2018).

29 Bala Iyer, Mohan Subramaniam, 2015, The Strategic Value of APIs, HBR (7 January 2015).

30 See the Chapter 3 for a definition of and distinction between 'digital wallets' and 'digital vaults'.

31 Economist, 2019, How to make banking fun (4 May 2019), "In South Korea ... The average adult has 5.2 bank accounts and 3.6 credit cards."

32 BBVA, 2019, BBVA, in alliance with Uber, launches first banking product in Mexico that operates in third party app (2 July 2019), "Through the Uber application, Uber's driver and delivery partners – as well as their families – can quickly and easily create a digital account linked to the international 'Driver Partner Debit Card,' [linked to Mastercard] directly receiving their earnings in a matter of minutes. Additionally, they will be able to access a platform with financial benefits – like loans– and non financial benefits – like discounts and reimbursements for gasoline purchases – with their driver partner card."

- It is no exaggeration to say that life in modern China is completely unthinkable without WeChat. Tencent's Blockbuster Super App is the flagship of China's mobile lifestyle, and integrates into all aspects of daily life.[33] Chinese users spend almost one-third of their time on WeChat, making it easy to gain traction on new features like Shake-shake, Friends Nearby, Walkie-Talkie, QR Codes, Official Accounts, Mini-Programs, or WeChat Pay.[34]

- Starbucks has the most-frequently used loyalty rewards app among major restaurant chains. The Starbucks app is the center of the company's digital ecosystem, bringing together ordering and paying in advance, creating Spotify playlists, loyalty rewards, mobile payment, and content partnerships.
- Kakao, a social media and mobile-gaming giant in South Korea, with a user base of almost 30 million, offers a digital wallet and itself operates the underlying bank account through its own bank 'Kakao Bank'.[35]
- Apple offers a digital wallet ('Apple cash account') in partnership with the bank Green Dot, which provides the underlying bank account and thus acts as digital vault for the USDs held therein.
- Facebook, the global social-media company with over 2 billion users, intends to launch its own digital wallet 'Calibra', which will only include the 'Libra coin' at first, but may extend to include the USD or CHF.

Beyond Banking

Banks have increasingly moved into non-banking services to counter falling margins in their traditional businesses and to fight back for the ownership of the customer relationship. A pioneer was Singapore's biggest bank, DBS,[36] which operates different marketplaces for cars, housing, and energy contracts, and earns commissions on the transactions.

Four main reasons have led to this development.

- First, *digitalization has increased/democratized access to information*. Customers can readily compare the services from different financial institutions, leading to increased price competition. Customers increasingly find information on the Internet for which they would have previously consulted a bank advisor.
- Second, *open-banking regulations* cut into banks' payment revenues, since payment orders can be triggered without having to rely on expensive payment schemes, and threaten banks' ownership of the customer relationship.
- Third, *digital-wallet operators may set up closed-loop systems*. Operators of digital wallets may connect only a single digital vault (e.g., bank account),[37] thus cutting out banks from payments between users of their digital wallet. Examples include Starbucks' and Apple's digital wallets (see 'Digital wallet wars' above).
- Fourth, new financial players have fueled the expectation that financial transactions can be, and thus should be, offered for free or almost free. Challenger banks, for instance, offered free account management, FX exchanges at interbank rate, zero-fee payment cards, digital wallets with zero fees for transactions to other wallet users. Big tech companies may furthermore offer free financial services by subsidizing the costs with the additional activity — additional revenues — that the price reduction on financial services generates in their core business.

Banks may become 'data brokers' for their clients. Financial institutions may build on their reputation as trusted parties to expand into data services. **Banks could act as trusted partners, helping data owners optimally monetize their data while preserving their privacy**. Potentially valuable, yet personally identifiable information, ranges from payment data, to vehicle data, health data, expense data, transit data, and social media data.

33 In the early days, WeChat prevailed against its opponents (Fetion of China Mobile and Miliao of Xiaomi).

34 Matthew Brennan, 2018, A Tale of Chinese Mobile Innovation: The Story of WeChat, China's Super App

35 Economist, 2019, How to make banking fun (4 May 2019), "within 13 days 2m people had signed up for current accounts and it now has 8.9m clients".

36 Economist, 2019, Reforming the Incumbents: Banker, Disrupt Thyself (4 May 2019), "The CEO of DBS met Jack Ma and realized that Alibaba would change the banking sector forever. This meeting left him determined to disrupt his own bank before Ant or another challenger had a chance and fought the start of new innovative models within DBS."

37 Digital-wallet operators may themselves provide a digital vault, or they may partner with a single digital-vault provider.

Ib. Store of Value

Persistent Strong Usage of Cash as a 'Store of Value'[38]
The popular saying that "Cash is king" ("Nur Bares is Wahres") lives on.

Large-scale data breaches and data hacking around the world have **kept confidence in digital technologies low**. The fear that the digital ledgers, registering assets ownership (e.g., digital money), could be hacked and/or robbed is widespread. A potential advent of quantum computing could further strengthen people's fears that no digital encryption is forever secured. **People continue to hold cash out of security concerns (theft) and privacy concerns (data breaches) relating to digital stores of value (digital vaults and wallets**).

People continue to hold cash out of security concerns (loss due to bankruptcy risks) relating to digital money held at commercial banks. The fractional reserve system puts people's deposited digital money at risk in case of bankruptcy. People are likely to still vividly remember the 2007 financial crisis and the many banks escaping bankruptcy only thanks to the help of governments. Their distrust of the banking sector remains high. And history indeed suggests that cash hoarding increases in the aftermath of financial crises and/or in the face of growing uncertainties.[39]

People continue to hold cash out of loss-of-value concerns (negative interests) relating to digital money. Independently of whether the negative interest environment persists, people are likely to be concerned about (a renewal combined with) banks carrying over the negative interests on their digital money deposits.

People continue to hold some cash to circumvent laws and regulations (illegal activities, tax avoidance). Cash has, however, reduced in importance as a means to circumvent laws and regulations due to the advent of digital assets (e.g., crypto-currencies such as Bitcoin) that are presumably privacy preserving, secure, and beyond the reach of governments.[40]

Increase of Nonmonetary Digital Assets as a Digital 'Store of Value'[41]
Everyone is an investor, investing their wealth directly or indirectly (via professional investors such as funds). The **share of wealth invested in nonmonetary assets has increased substantially**. These two developments were driven by:

- *Democratization of the investment space* due to ETFs, index-tracking funds, robot-advisors, robo-funds, increased financial literacy, zero-trading-fee brokers, direct-access zero-fee online trading platforms, and digitalization of rights to assets.[42]
- Aging population and loss of trust in pension funds' ability to meet their future obligation.
- *Reduced wealth prospects from labor*[43] has driven people into the investment arena with the hope of capturing some of the wealth created by the economy — investment has become something of a national pastime.

Nonmonetary digital assets are thus increasingly replacing/substituting digital money as a digital 'store of value'. For some, it was the promise of higher returns leading them to deploy their capital instead of letting it sit idle in bank accounts. While others were driven by risk diversification and/or the belief that nonmonetary assets are simply a safer store of value. Besides equities, bonds, and funds, nonmonetary digital assets include among others[44] digital (ownership or

38 Sharing this view: Schweizerische Bankiervereinigung, 2019, Wer brauch denn noch Bargeld? Diskussionspaper der SBVg (September 2019), „Bargeld ... wird auch in der Schweiz auf lange Sicht ein relevantes Zahlungsmittel und Werterhaltungsmittel bleiben."

39 Cash hoarding substantially increases in the aftermath of the break-up of the Bretton-Woods system in the 1970s, the burst of dotcom bubble in 2000, and the global (mortgage) financial crisis in 2007. See e.g., SNB, 2019, The Demand for Swiss Banknotes: Some New Evidence, SNB Working Papers (February 2019).

40 See also footnote 49.

41 See Chapter 3 for definitions of digital assets, and of monetary and nonmonetary (digital) assets.

42 See the most likely scenario of SIX, 2019, 'Future of Financial Information' for a discussion of why we may expect the rights to almost all (digital) assets to be digitally represented.

43 The millennial generation is the first generation to be worse off than their parents; see e.g., Christopher Kurz, Geng Li, Daniel J. Vine, 2018, Are Millenials Different?, FEDS Working Paper No. 2018-080.

44 See the alternative scenario 'Central Banks Are Dead, Long Live Central Banks!' for more details on some of these digital assets.

usage) rights to flyer miles, fine art, collectibles, data,[45] gold,[46] diamonds, real estate, Facebook's Libra Coin, JPM Coin, UBS' Utility Settlement Coin, Walmart's Coin, Fortnite's V-Buck, and Safaricom's M-Pesa.

Zero Technical Switching Costs

Anyone can readily join a digital-vault provider. Customers can set up a digital vault (e.g., digital bank account) with a simple login using a widely trusted digital identity provider.

Switching between digital vaults is seamless. Third-party digital wallets can automatically switch connectivity from the old digital vault to the new one. In some countries, account numbers of digital vaults have even become portable.[47]

Ic. Payment

Cash Continues to Retreat as a 'Medium of Exchange'

Digital payments have relentlessly pursued their imperialistic march, becoming the means of payment in ever more instances (see below).[48] **Usage of cash for payment has fallen by 40-70%**.

Even illegal activities have shifted away from cash due to the advent of new digital means of payment (e.g., crypto-currencies such as Bitcoin) that are presumably privacy preserving,[49] secure, and beyond the reach of governments.[50]

Nonetheless, **cash has not been completely phased** out as a medium of exchange. Cash has continued to be used in several instances, to name just a few:

- Non-digitally inclined people (e.g., the elderly) continue to rely on cash. The unbanked (e.g., the poor) continue to rely on cash for lack of alternatives. To protect these citizens, governments have at times passed laws requiring (certain) merchants to continue accepting cash for fear of discrimination.[51]
- Some people continue to rely on cash for self-regulation to keep their spending in check.[52] They view cash as providing a higher level of control over their spending: They expect the pain of paying with cash to be higher, and carry cash around hoping to reduce impulse purchases.[53]
- Some people continue to prefer the tangibility of cash to the abstract, intangible digital money.
- Some parents continue to rely on cash to teach their children the value of money.
- People, including merchants, concerned with the security and privacy of digital means of payments continue to rely on cash.[54]

People may continue to hold some cash as a back-up means of payment: People concerned with the availa-

---

45 For a broad discussion of how 'rights to data' might evolve in the future, see the most likely scenario in SIX, 2019, 'Future of Financial Information'.

46 Digital asset backed by tangible gold that is held in custody by a third-party. See e.g., Digital Swiss Gold (DSG), Novem, and Royal Mint Gold (RMG).

47 Like 'phone number portability'.

48 Economist, 2019, The Dash Off Cash: Rich countries must start planning for a cashless future (1 August 2019), "In Sweden the number of retail cash transactions per person has fallen by 80% in the past ten years. Cash accounts for just 6% of purchases by value in Norway. Britain is probably four or six years behind the Nordic countries. America is perhaps a decade behind. Outside the rich world, cash is still king. But even there its dominance is being eroded. In China digital payments rose from 4% of all payments in 2012 to 34% in 2017."
In 2017, 70% of transactions, but only 45% of transacted value, were processed in cash in Switzerland; see SNB, 2018, Report on Payment Methods 2017 (May 2018).

49 See e.g., Roger Wattenhofer, 2019, Zur Zukunft unserer Bezahlsysteme: Bar, Plastik oder Krypto?, Schauffhauser Nachrichten (8 August 2019), „Es gibt Kryptowährungen wie Zcash, die so anonym wie Bargeld sind."

50 Close to 50% of all bitcoin transactions and 25% of all bitcoin users seem to be associated with illegal activities; see e.g., Sean Foley et al, 2019, Sex, Drugs, and Bitcoin: How Much Illegal Activity Is Financed Through Cryptocurrencies?, Review of Financial Studies 32(5), 1798-1853.

51 Several cities in the US have passed, or are considering passing, a 'cash-acceptance requirement' for merchants to avoid discriminating against certain segments of the population. Philadelphia became the first major US city to ban cashless stores from 1 July 2019; New Jersey, New York City, Chicago, and Washington are all considering similar measures. See e.g., Finextra, 2019, Philadelphia bans cashless stores (8 March 2019).
Schweizerische Bankiervereinigung, 2019, Wer brauch denn noch Bargeld? Diskussionspaper der SBVg (September 2019), „Ein Blick nach Schweden, dem Vorreiter beim bargeldlosen Zahlungsverkehr in Europa, bestätigt dies. Kurz vor der restlosen Abschaffung des Bargeldsziehen Politiker, Ökonomen und die Schwedische Notenbank die Notbremse und warnen vor den Konsequenzen der Bargeldabschaffung und dem damit verbundenen Ausschluss gewisser Bevölkerungskreise vom wirtschaftlichen Leben."

52 Drazen Prelec, Goerg Loewenstein, 1998, The Red and the Black: Mental Accounting of Savings and Debt, Marketing Sciences 17(1), 4-28.

53 Some, though not all, experimental studies have found that paying with cash reduced 'bad' purchases. See e.g., Manoj Thomas et al, 2011, How credit card payments increase unhealthy food purchases: Visceral Regulation of Vices, Journal of Consumer Research 38(1), 126-139.
Carrying around cash is arguably more of a 'felt control': Since purchasers are likely to carry payment cards with them as well, they may easily switch between means of payment at the moment of truth.

54 Refer also to the discussion of why people continue to hold cash as a store of value in Section 'Ib. Store of value'.

bility of digital payment in the event of a blackout and network interruption may continue to carry around some cash to be safe[55]. These people may, however, never pay with this cash — it is only a backup for the event of a blackout or network interruption.

Cash's Next Iteration: Smart Banknotes

Smart banknotes[56] have slowly spread and coexist alongside their traditional (non-smart) variety. Smart banknotes can have all the benefits of traditional cash and more: When they have an integrated chip, they are as immune as cash to blackouts and network interruptions and they can be as privacy (anonymity) preserving as cash, while being more secure than cash.[57]

The advent of smart banknotes has slightly slowed down digital payments' march for two reasons.

- ***The introduction of smart banknotes has slightly increased people's willingness to carry cash*** by reducing the risks of robbery: In the event of a dangerous situation, the smart banknote can instantly be deactivated. Deactivated smart banknotes are only worth the paper they are printed on.
- Ever more merchants had completely stopped accepting cash to avoid the costs associated with handling it. ***The introduction of smart banknotes has slightly increased merchants' willingness to accept cash for payment*** by reducing their cash handling costs to virtually zero. The smart banknotes can readily be deactivated,[58] which automatically deposits the equivalent of the banknote's denomination (face value) into the merchant's digital bank account.[59] Merchants no longer have to carry suitcases full of cash to their bank, and do not have to worry about thieves stealing their physical vaults.

Digital Payments Take over Shopping

Digital payment has become significantly more convenient than cash in physical shops. Digital payment experienced its first jump in convenience with self-scanning and self-checkout. Although customers still had to go to a dedicated checkout area to pay (and sometimes scan), they no longer had to wait in checkout lines operated by human cashiers.

The next jump in convenience occurred as customers were able to scan the products on the shelf with devices connected to their digital wallet. Customers could directly pay within their digital wallet, without having to make a detour via a dedicated checkout area. One example was SATURN's Smartpay app, which turned the smartphone into a digital shopping cart, products were added via the camera (barcode scanning) or via NFC, and which had digital payment directly embedded.

The final jump in convenience took place when customers no longer needed to scan the products themselves, with sensors and cameras tracking customers' every move and automatically adding the products they took off the shelves to their digital shopping cart.[60] The payment was automatically initiated when customers left the shop.[61] Early adopters of fast mobile payment methods and payment directly at the shelf were smaller stores in cities, where customers tended to be more pressed for time, and less price-sensitive than customers at larger department stores.

Physical shops are increasingly being replaced by digital experiences.[62] New technologies (AR, VR, neurotech) provide a holistic immersion for all senses: We increasingly cannot distinguish the real thing from the virtual experience.[63] Besides seeing, touching, and feel-

---

55 See the discussion on 'Secure and privacy-preserving communication pipes' in Section 'IIc. Underlying technology' of our most likely scenario.

56 Smart banknotes are pieces of paper that have no value. Once they are activated, they are worth the denomination written on them — they worth their face value. See Section 'IIa. Cash' for a description of how this activation/deactivation process works.

57 See Section 'IIa. Cash' for a detailed description.

58 The cash register can scan the banknotes and deactivate them automatically.

59 See Section 'IIa. Cash' for a description of how this activation/deactivation process works.

60 This process needs to involve facial authentication/recognition. Customers may link themselves to a digital wallet when entering the shop by placing their smartphone at an NFC interface. The image recognition algorithms can then link the visuals of a given customer to a digital wallet, and track that customer throughout their journey in the shop via the cameras (without having to run any facial recognition algorithms).

61 Some customers may want more control over payments initiated from their accounts, opting to receive a one-click payment validation just before leaving the shop.

62 Going even further: GDI, 2019, The End of Consumption as We Know It (February 2019), page 5, "The terms 'retail' and 'department store' will become extinct ... Physical stores full of stuff will become irrelevant ... The music industry is a case study for the future of the retail industry. Music is still in demand and a healthy business; music stores have disappeared."

63 Going even further: GDI, 2019, The End of Consumption as We Know It (February 2019), page 54, "virtual worlds will not only be heard and seen in [the] future, but experienced holistically ... Thanks to immersion it will be possible to experience the entire intensity of the real experience, even if you are sitting comfortably on the sofa at home."

ing objects, we can also virtually place them in our homes, and virtually try them on to see how, for example, a jacket would fit and look. **Shopping increasingly takes place in these virtual worlds — where digital is the natural means of payment**.

Finally, **if smart banknotes do not gain traction, physical merchants may increasingly stop accepting cash as a means of payment[64] or increase the price of goods purchased with cash.[65]** Traditional cash as a means of payment entails substantial costs for its users. Whoever carries cash risks losing or having it stolen. Whoever accepts cash as payment faces the same risks, and must additionally bear the costs of handling it — from operating a cash register, to owning a physical vault, and safely transporting the cash to the home bank.

Digital Payments Also Displace Cash Everywhere Else

We have seen above that digital UIs are natural parts of ever more human activities.[66] **Digital payments are seamlessly embedded in the digital services (e.g., apps, websites, AR, chats) running on digital UIs, making them more convenient than cash in all contexts marked by a significant digital UI presence**. Take the Uber experience. You call an Uber driver from the app at the airport, get in the Prius, and when arriving at the hotel, the payment is automatically initiated from within the app (GPS-location based). Depending on your settings, you may receive a push notification of the debited amount from your bank.

Voice interfaces have spread digital payments even to the human activities in which digital UIs have not become an integral part by making digital payment more convenient than cash there as well. Siri could already help users carry out peer-to-peer (P2P) transfers in ZKB's TWINT app in the mid-2010s.

Furthermore, **digital payments can automatically and seamlessly be launched by the rapidly growing number of Internet-connected devices (Internet of Things),[67]** further contributing to making digital payments again much more convenient than cash. Internet-connected cars, for instance, automatically initiating payments from the digital vault you linked to the car, at gas stations or on toll roads. This is similar to how services (e.g., newspapers) automatically trigger payments (via the stored credit card information) when a subscription is up for renewal.

Disappearance of Payment Cards as Authenticators

Physical debit/credit cards have disappeared. People may still carry them around out of habit, but they almost never take them out of their wallets.

Where a physical payment terminal still exists, customers may use ***digital wallets*** on their Internet-connected devices, such as a smartphone or AR glasses,[68] to authenticate themselves at their bank and trigger the digital payment. In other physical experiences, customers' ***biometric data*** is used, from fingerprint scanning, to facial recognition, retinal scanning, and gait analysis.

In the digital realm, customers can embed/connect their digital wallets directly into digital services from mobile apps, websites, VR environments, chats, and voice calls.[69]

The disappearance of payment cards may only be from sight, not from usage as they may continue operating in the background, stored in digital wallets and automatically used for authentication at banks.[70] However, **general-purpose digital IDs have increasingly been replacing payment cards as authenticators in digital wallets** as well. These digital IDs are likely to build on biometrics to establish second-factor authentication.

Digital Payments Are Settled Instantaneously

Instant payment enables companies and private individuals to pay in seconds, simultaneously crediting and debiting the respective accounts. This must be distin-

64 An increasing number of stores already stopped accepting cash in the 2010s in the Netherlands, Scandinavia, and China. See e.g., BBC, 2016, The countries where cash is on the verge of extinction (29 September 2016), L'Agefi, 2019, L'ère de la société sans cash approche (23 August 2019).

65 Governments could even consider mandating such price differences in order to help their central bank reduce its interest rates far below zero; see footnote 118.

66 See Section 'Ia. General developments'.

67 Some forecasts put the number of internet-connected devices/things by 2035 at one trillion — one hundred per human being. See, for instance, Economist, 2019, Connected Computers: Chips With Everything (14 September 2019).

68 These Internet-connected devices rely on an NFC interface, QR code scanning, or voice interface to understand how much to transfer to what bank account.

69 Thus replacing the storage of ‚'payment card details' in these digital services. Think 'Google Pay' buttons.

70 Sharing this view: Roger Wattenhofer, 2019, Zur Zukunft unserer Bezahlsysteme: Bar, Plastik oder Krypto?, Schauffhauser Nachrichten (8 August 2019).

guished from 'felt instant payment' (or 'pseudo instant'). Twint, for example, only provides the latter: Although the client is immediately informed of the transfer, the money is only credited/debited to/from the accounts later. Such **pseudo instant solutions still dominated the market in the mid-2010s**.

An Increasing Number of People Regularly Pays with Nonmonetary Digital Assets[71]

We have seen above that people hold a growing share of their wealth in nonmonetary digital assets, replacing digital money as their digital 'store of value'.[72] **They can — and a majority does — 'pay' for goods and services with nonmonetary digital assets** such as equites, bonds, funds,[73] digital rights to gold, digital rights to your data,[74] your time,[75] a like from you, and/or a Tweet from you ('Pay with a Tweet').[76]

Since the merchant is unlikely to want the nonmonetary digital asset(s) one is willing to pay with, **the transaction generally continues to involve money in the background:** An intermediary may be placed between buyer and seller, taking on the nonmonetary digital asset, and paying the merchant in digital money.[77] In other words, **the buyer actually sells their nonmonetary digital asset(s) in real-time** for digital money, and then transfers the digital money to the seller.[78] All of this takes place in less than a blink of an eye and completely seamlessly.

A Minority Starts Using Nonmonetary Digital Assets as Their Unit of Account

People can opt to see the value of their assets and the prices of goods/services displayed in terms of any reference asset. This is made possible by digital UIs and augmented reality.

Take online gamers. They grew up spending their free time in Fortnite's virtual gaming environment, perhaps even selling their own services in it. Having thus gotten used to Fortnite's digital currency V-Buck, they may have become accustomed to evaluating assets in those terms. At jobs interviews, they may even translate the starting salary into V-Bucks, similar to how an expat would translate it into their home currency.

---

71 See Chapter 3 for definitions of digital assets, and of monetary and nonmonetary (digital) assets.

72 See Section 'Ib. Store of value'.

73 Believing this could happen for certain types of funds: Tobias Adrian, Tommaso Mancini-Griffoli, 2019, The Rise of Digital Money, IMF Fintech Notes (15 July 2019), page 5, "Private investment funds — such as money market funds, and exchange-traded funds — offering relatively safe and liquid investments".

74 This is nothing new: We have all been paying with 'usage rights to our data' for services such as Gmail and Facebook. With all the digital data we are constantly producing, there may be something interesting for most sellers. See SIX, 2019, 'Future of Financial Information' for an overview of this data, and for a discussion of how everyone might in the future be empowered to sell 'usage rights to their data' without compromising data privacy and security.

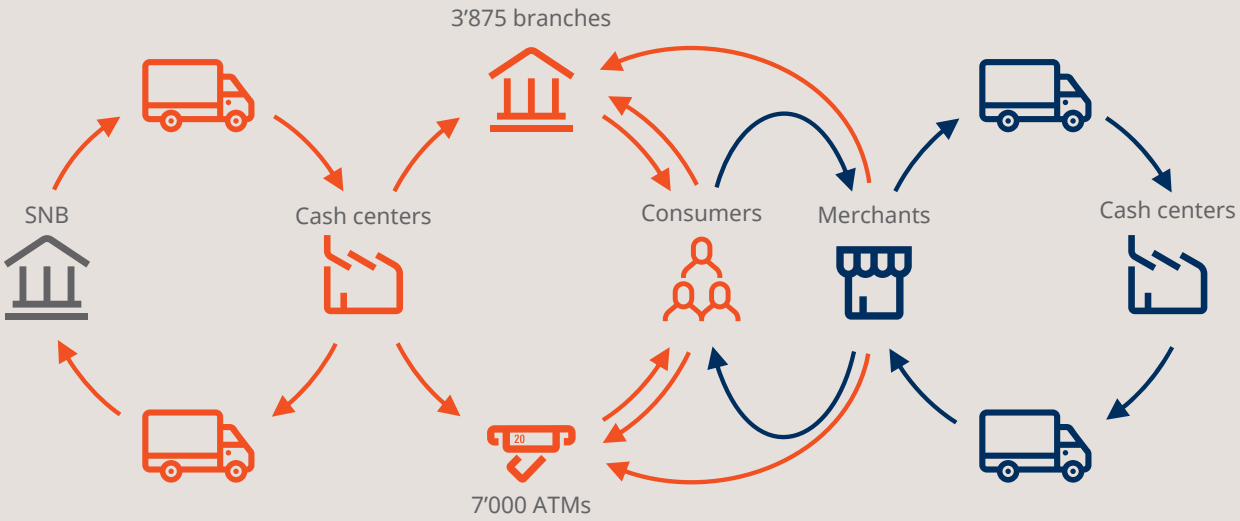
75 The St. Galler Zeitvorsorge is an innovative 'non-simultaneous time credit system' for the care and support of elderly people in need of help. See Zeitvorsorge St. Gallen (http://www.zeitvorsorge.ch/).

76 See footnote 43 and the text following it for additional examples of 'nonmonetary digital assets'.

77 Such intermediaries are akin to liquidity providers (market makers) in the trading of financial products.

78 Note that if partitioning of the nonmonetary digital assets is small enough (fractionalization), the exact amount needed can be sold.

Estimated Annual Operating Costs of the Swiss Cash Infrastructure in 2019*



Cost for SNB	Cost for bank sector	Cost for retail sector
~ 130 mio CHF	~900 million CHF	1.3 bn CHF

* This cost estimation only captures cash as a medium of exchange.

II. Money Infrastructure

IIa. Cash

Contrary to the popular belief that cash is free, **the operation of the underlying cash infrastructure entails annual costs of around 2.3b CHF** for the economy.[79]

Cash holdings have declined by 40-60%, mainly driven by a fall in usage of cash as a means of payment by 40-70%. Although cash is still widespread — and has perhaps even increased — as a 'store of value', its usage has substantially declined as a 'means of payment'.[80]

Centrally Operated National Cash Infrastructure

Ever more people live in cities and conurbations, reaching over 60% of the world's population[81]. The customer base in **rural areas can no longer cover the costs of viably operating multiple cash infrastructures at a reasonable (non-discriminatory) price**.

Investors have continued to put pressure on banks to run their operations more efficiently. Reducing the substantial costs of operating the cash infrastructure was not excluded from these demands.

The physical ATMs, the software, or the transport of cash to-and-from ATMs all benefit from economies of scale (cost mutualization, scale-based optimization).[82] Banks have collaborated to set up a player to provide and operate the entire cash infrastructure on their behalf.[83] Although the collaboration started with a focus on rural areas,[84] once efficiency gains were realized, it quickly expanded into urban areas as well.

The provision of the entire national cash infrastructure has been delegated to a single operator (utility) to benefit from economies of scale. All customers of participating banks can withdraw money free of charge. All transactions from member banks are treated as on-use transactions.

The number of ATMs has declined by 30-40%.[85] ATMs from different banks covering the same geographic region have been eliminated. The spread of crowd-sourced cash infrastructure (see below) has also allowed a reduction in the number of ATMs.

Everybody Is Part of the Cash Infrastructure

Digital wallets with P2P functionality made anyone part of the cash infrastructure. Anyone became a walking ATM: You could give a friend or an Uber driver cash, and they could send you the equivalent amount as digital currency into your digital bank account. You can scan whether anyone in your surrounding is willing to give out cash in exchange for digital currency.[86]

---

79 For a cost estimation of the Swiss cash infrastructure, see Exhibit 3 on page 30.
Schweizerische Bankiervereinigung, 2019, Wer brauch denn noch Bargeld? Diskussionspaper der SBVg (September 2019), „Bargeld ist ein Kostenfaktor ... Diese Kosten sind im Alltag kaum sichtbar, fallen aber zahlreich an, sei es im Handel beim Transport, beim Abfüllen von Bancomaten, bei der Lagerung, für die Versicherung oder bei der Bereitstellung und Entgegennahme durch die Banken. Weiter verursacht auch der Notendruck Kosten. Die Herstellungskosten einer Banknote belaufen sich gemäss SNB im Durchschnitt auf rund 40 Rappen, d. h. umgerechnet auf eine 10er Note betragen die Produktionskosten vier Prozent."

80 See Sections 'Ib. Store of value' respectively 'Ic. Payment'.

81 See e.g., OECD, 2015, The Metropolitan Century: Understanding Urbanisation and Its Consequences (18 February 2015), page 1, "Already today, more than 50% of the world's population lives in cities. This figure is projected to reach 85% by 2100. Within 150 years, the urban population will have increased from less than 1 billion in 1950 to 9 billion by 2100."

82 Separate, independently operating infrastructures may each optimize for themselves, yet fail to optimize across all of them.

83 Economist, 2019, The Dash Off Cash: Rich countries must start planning for a cashless future (1 August 2019), "There is a high cost to running the infrastructure behind the cash economy — ATMs, vans carrying notes, tellers who accept coins. Most financial firms are keen to abandon it, or deter old-fashioned customers with hefty fees."

84 No bank has enough scale in the rural areas: No bank has a sufficient customer density in the rural areas to offer the cash infrastructure at low enough prices.

85 There were around 7,000 ATMs in Switzerland in 2019; see SNB, Datenportal, Volkswirtschaftliche Daten: Zahlungskarten und Geldausgabeautomaten. This number is expected to fall to 4,000-4.500 ATMs.
After several years of slowing annual growth, the number of ATMs worldwide finally fell in 2018. See e.g., Richard Cummings, 2019, How ATM deployers are addressing changing market dynamics, Self-Service Banking Europe (22 May 2019).

86 Solutions focus on preserving privacy and security of participants. If you request cash, an equivalent amount of digital currency is transferred from your account to an escrow account. Any surrounding person with the app then receives a notification: They can see the details of where you are and of who you are. They can then walk up to you and wait until the last moment to decide whether or not to accept the exchange. During this entire process, the 'person with cash' is never revealed until the moment of the exchange.

Merchants (P2M) can be asked to hand out cash, or to deposit money into your digital bank account in exchange for cash. The first iteration built upon payment cards, adding cash-out functionalities (cash-out cards). **Merchants have also been enrolled to deposit their cash directly in ATMs.**

In rural areas, P2M has led to an almost-circular cash economy. Locals take out cash from the single local ATM, pay with this cash at local stores, and merchants deposit the cash back in the local ATM, thus closing the circle. This closed loop does not, however, exist when consumers take out cash from one ATM and pay with it in the proximity of another ATM.[87] This is especially the case in urban centers. The cash infrastructure operator must then direct cash-holding merchants to the right ATMs and/or transport the cash between ATMs.

Traditional cash infrastructure risks disruption from crowd-sourced (P2P, P2M) cash infrastructure. Such a cash infrastructure may not only run more efficiently (lower cost for equivalent usage and coverage), it may also be more convenient by bringing the 'ATM' to virtually everywhere (i.e., better coverage).

Smart Banknotes Infrastructure Sees the Light

Cash has gone smart: Smart banknotes have slowly spread and coexist alongside their traditional non-smart variety.

Smart banknotes can be activated and deactivated. An activated banknote has the value of its face value — of the denomination printed on it. A deactivated banknote is only worth the paper it is printed on. **Smart banknotes are pieces of paper that have no value, until they are activated**.

When a person activates a smart banknote, digital money from the activator's bank account is automatically transferred to the issuer of the smart banknote. And when a person deactivates a smart banknote, the reverse happens, digital money is transferred to the deactivator's digital account from the issuer. *In short, activation/deactivation launches a transfer of digital money between the bank accounts of the (de)activator and the issuer.*

The activation status of a smart banknote may be stored in an online database or on a chip in the banknote. In both cases, the value is lost if the activated smart banknote is lost or destroyed, just as with traditional banknotes.

Smart banknotes can be as immune to blackouts and network/connectivity interruptions as traditional cash. If the activation status is stored on a chip in the banknote, no Internet connectivity is necessary to check the status — it continues to be useable during blackouts and network interruptions.[88] The activation status of a smart banknote can be displayed on the banknote by a sensor, or it can be checked via a reader.[89]

Activations/deactivations of smart banknotes can be as privacy preserving (anonymous) as traditional cash despite requiring a transfer of a digital currency from one account to another. In the following, we only discuss 'activation', but it also holds in reverse for 'deactivation'.

- An ATM (or a third party) can activate a large number of smart banknotes in advance, shuffle them, and randomly dispense them. The digital money transferred (to the ATM operator) by the person using the ATM could thus not be linked to a specific smart banknote.
- Even when a person activates a smart banknote, privacy-preserving mechanisms may be built directly into the digital database/ledger, preventing any linking between the 'bank account' and a 'smart banknote'.[90]

Smart banknotes are more secure than traditional cash. In the event of a dangerous situation (e.g., potential robbery), the smart banknotes can instantly be deactivated.

87 In particular, the circularity does not exist when there are multiple ATMs in a given area. Merchants will not know which ATM to deposit the money at, and consumers may over time use different ATMs to take out cash.

88 The chip requires minimal electricity to check its activation status. A small external power source may bring the chip to life, for example from a solar panel, smartphone, or any device emitting radio waves (the chip on contactless credit cards works in this way). The chip may also harvest ambient energy, through movement/vibration (via a micro-kinetic energy generator built into the smart banknote), sunlight or heat.

89 A smartphone can communicate directly with the chip to query its activation status.

90 For instance, all digital currency transactions are sent from your digital vault to an intermediary account, including the encrypted information on the destination account. Only the intermediary account can decrypt this information. The intermediary account waits until it has accumulated multiple transactions, and then in random order sends the digital currency to the destination accounts. There is no way to link destination account to a specific originating digital vault. Another approach may be to rely on 'zero-knowledge proofs'. A notable experiment implementing this approach is the zcash crypto-currency (see footnote 48).

Putting it all together, when smart banknotes have an integrated chip, they have all the benefits of traditional cash and more.[91] **Traditional cash infrastructure risks disruption from smart banknotes infrastructure**. Whether traditional cash is disrupted ultimately depends on the production costs of smart banknotes with integrated chips.

Several candidates for issuing smart banknotes are imaginable. The CB may issue a smart banknote alongside its traditional banknote in an effort to test this new technology and to prevent private actors from displacing CB-issued banknotes. A commercial bank could issue smart banknotes, or big tech companies could issue them — think of a smart Libra banknote.

IIb. Digital Money

Instant Settlement Goes Mainstream

The underlying infrastructure must **provide instant settlement — including for payments with nonmonetary digital assets**. This is less straightforward than it seems: When a person pays with a nonmonetary digital asset, the transaction may not amount to a barter. An intermediary is then needed to take on the nonmonetary digital asset and transfer digital money to the seller.[92] People expect this entire process to be seamless and instant as well.

Digital-Assets Infrastructure Lying in Ambush

Digital currency/money is simply a special case of digital assets. Issuers of digital money, such as banks or central banks, may decide to build upon a state-of-the-art digital ledger infrastructure that can handle any digital asset.[93] Indeed, these general-purpose digital-assets infrastructures benefit from massive investment from all around the world and are therefore likely to exhibit higher innovative capacity and economies of scale. **Incumbent money infrastructure risks disruption from modern digital-assets ledger infrastructures.**

Infrastructures Are Fully Programmable

The infrastructure for digital money empowers anyone to write and run programs that directly link/reference digital money.[94] Users and service providers can readily write self-executing contracts that automatically trigger a money transfer. For instance, the interest payments in a debt contract, or the freeing of money held as collateral in an escrow account.

Regionalism[95] in Payment Schemes

Global payment schemes may be weaponized by governments to achieve political goals: *Global payment schemes could be prohibited from servicing certain foreign countries or from doing business with certain foreign companies*.

The USA was at the forefront of deploying economic tools more generally for political ends.[96] *Global payment schemes could be used by governments to spy on foreign citizens or to steal data (the 21st century's key resource)*.

The rising wave of anti-trust cases against big tech companies may spill over into other areas: *suspicions may grow that global payment schemes might not be playing fair*, buying politicians and abusing their market dominance.

For all these reasons, global and foreign payment schemes from the USA (Mastercard, Visa) and Asia (Alipay) are increasingly perceived as potential risks. **Governments have mandated the establishment of**

---

91 See Section 'Ic. Payment'.

92 See Section 'Ic. Payment'.

93 These digital ledgers may operate as central ledgers or permissioned distributed ledgers.

94 Brett King, 2018, Bank 4.0: Banking Everywhere, Never at a Bank (Marshall Cavendish: Tarrytown, NY), p. 170, "money must become intelligent to retain utility and function".

95 We follow the International Relations definition of international regionalism. Seminally, see Joseph S. Nye, 1968, Introduction, in Joseph S. Nye (ed.), International Regionalism: Readings (Little, Brown and Company: Boston, MA), page vii, "the formation of interstate associations or groupings on the basis of regions".
'Regionalism' is not to be confused with 'regionalization': The latter describes increasing commercial/human transactions at the regional level.

96 Economist, 2019, Weapons of Mass Disruption (8 June 2019), "America is aggressively deploying a new economic arsenal to asset its power ... to protect [and advance] its national interest."

national/regional payment schemes.[97] Europe may seize the opportunity to launch its own payment scheme in the SEPA region — reminiscent of the 1960s and the Eurocheque system.

Isolated regional payment schemes have not prevailed because people want their digital means of payment to work anywhere — with any merchant, in any country, in both online and offline settings. **National/regional payments schemes are interoperable with other payment schemes, but can run in isolation (autarky) as well**.

Possible Turnaround in Payment-Data Flows

The authentication and payment data used to originate from merchants. When customers paid with a physical payment card, the merchant's terminal or online checkout sent the authentication and payment-trigger request to the customers' bank, which would then launch the payment. Payment schemes operated the platform in the middle, connecting the millions of merchants with the thousands of banks, to route the payment data from a specific merchant to the customer's bank.

As customers carry Internet-connected devices, from smartphones to AR lenses, the origin of the data may switch to the customer. Specifically, the digital wallets on the customer's Internet-connected device can collect the data from the merchant's physical checkout,[98] and then send it to the customer's bank to launch the payment,[99] without any communication platform operated by a payment scheme needed in between. The same is true in the digital realm: **Customers can embed or connect their digital wallets into/to third-party digital services,**[100] so that it can collect the data from the merchant's digital checkout in order to send it to the bank.

Payment Schemes Face the Heat

As mentioned before, payment schemes have historically routed payment data from the merchants' physical and online checkouts to the customer's bank. Incumbent **payment schemes (e.g., Mastercard, Visa) face increasing competition and substitution risks as the number of alternative communication pipes, allowing customers to send payment data to their bank, rises**. We distinguish between three types of alternative communication pipes:

- *National/regional payment schemes,*[101] allowing merchants and customers to bypass global payment schemes in local transactions.
- *Pipes connecting digital wallets directly with banks,*[102] allowing customers' digital wallets to directly send payment orders to the connected bank accounts.
- *API-based*[103] *pipes connecting any digital service to bank accounts,*[104] allowing merchants to directly send payment data to a customer's bank account.[105]

Although digital wallets and merchants could directly communicate with bank accounts via these APIs, an API aggregator may act as intermediary, providing a standardized API to the many different bank APIs, and avoid-

97 From a member of the Executive board of the ECB: Yves Mersch, 2018, Strengthening the European financial industry amid disruptive global challenges, Speech at EIFR (3 September 2018), "Our reliance on non-European card schemes for domestic payments in Europe is suboptimal".
Both the Brazil National Bank and the India Reserve Bank have initiated national (debit) payment schemes. The Brazilian scheme 'Elo' was launched in 2011. And the Indian scheme 'RuPay' was launched in 2012.

98 The digital wallets may rely on an NFC interface, QR code scanning, or voice interface to understand how much to transfer to what bank account.

99 This connectivity is identical to how you do not need a payment card to access your online bank account, from which you can directly trigger digital payments (again without any involvement of a payment card).
Note that if a payment card is used as authenticator in the digital wallet (see footnote 69 and the text surrounding it), then nothing may have changed since the payment data may be routed through the communication platform of the payment card's payment scheme.

100 See footnote 68 and the text surrounding it.

101 See the discussion on 'Regionalism in payment schemes' above.

102 See footnote 98 and the text surrounding it.

103 See the discussion on governments mandating banks to open up their interfaces ('open-banking regulations') in Section 'Ia. General developments'.

104 These are exactly the types of pipes that were provided by incumbent payment schemes (e.g., Mastercard, Visa).

105 Amazon could thus trigger payment orders from customers' bank accounts without relying upon Mastercard or Visa. The Deutsche Bank is currently running a pilot with the International Air Transport Association (IATA) that would allow airlines to directly access the customer's account to trigger the payment for a ticket, thus bypassing payment scheme transaction fees. See e.g. e-tailment, 2019, Run aufs Konto: Die wilden Ideen der Finanzbranche (4 April 2019).

ing everyone having to individually connect to thousands of different banks.[106] **Payment-API aggregators may become the new payment schemes.**

IIc. Underlying Technology

Open-Source-Based It Infrastructure

Open source software has finally been adopted in the financial space. **Open source allows users to massively reduce costs and avoid lock-ins with specific technology vendors**. Since the source code is open to everyone, **security gaps and bugs in codes are more rapidly identified**.

Relying upon open source software has also **increased financial institutions' innovation capacity**: Companies can draw from an enormous pool of programmers and software companies to build solutions for them.

Micro-Services-Based It Infrastructure

While API tools have always played an important role in software development, **software programs are now deconstructed into their constituent parts**, and the individual parts linked to each other via APIs.

This shift has **massively reduced the costs of maintaining and upgrading the IT stack**. Instead of having to upgrade a monolith in its entirety, typically requiring an enormous cross-functional IT project, individual elements can piece by piece be upgraded in isolation and then be plugged back in.

Micro-services-based IT has also **increased financial institutions' innovation capacity**: Any employee can seamlessly combine existing micro-services with new elements, without having to rebuild existing modules or having to wait for support from the IT department to build the necessary interfaces to existing modules buried in the monoliths.

Secure and Privacy-Preserving Communication Pipes

Cyber-threats have continued to increase. Cyber-attacks have been perpetrated by increasingly sophisticated cybercriminals, from nation-states, to corporations, criminal syndicates, and terrorist groups. The reasons for attacks have ranged from destabilizing foreign governments/economies (cyberwarfare),[107] to stealing data ('the natural resource of the 20th century'), blackmailing individuals and companies (e.g., threatening to reveal private data), stealing IP/strategies (corporate espionage), and paralyzing competitors' businesses.

The digital communication pipes — on which digital UIs from ATMs, to mobile apps (e.g., digital wallets), to payment terminals run — **are particularly at risk**. These communication pipes send data outside the confines of one's protected private network or smartphone app, into the public Internet, which was not designed for high security. A fundamental rebuild of the underlying Internet architecture/protocol may be needed.[108]

Since cyberattacks may target electricity grids, network operators, or Internet service providers (ISPs), **the risk of blackout and network-interruption events has increased substantially**.

The costs of a successful cyberattack on the financial system could be substantial, halting economic activity and preventing access to necessity goods. Imagine a cyberattack on Switzerland that not takes out electricity grids and Internet connectivity, but also wipes clean

106 See, for instance, Klarna's API hub: e-tailment, 2019, Run aufs Konto: Die wilden Ideen der Finanzbranche (4 April 2019), „Das funktioniert ganz ähnlich wie die jüngst vom schwedischen Zahlungsanbieter Klarna angekündigte Open-Banking-Plattform für Drittanbieter. Das Angebot: Der Zugang zu über 4.300 Banken und deren Bankkunden in über 14 europäischen Ländern auf Basis einer Schnittstelle. Über diese Plattform können andere Firmen auf die Kontoinformationen zugreifen und auch Zahlungen auslösen - vorausgesetzt, deren Kunde stimmt zu."

107 For instance, through political election interference/ manipulation, through interruption/malfunction of critical infrastructure such as electricity, or through paralysis of a country's food supply (e.g., by attacking farmers' connected devices).

108 One such clean-slate design approach is the SCION project developed by ETHZ (https://www.scion-architecture.net/). It enables end-to-end route planning of data through the public internet, and thus ensures that your (encrypted) data only transits through trusted nodes to reach its destination. Such approaches are known as path aware internet communication protocols.
The Swiss National Bank furthermore suggests that a secure communication infrastructure for the Swiss financial sector might fundamentally build upon SCION; see Andréa M. Maechler, Thomas Moser, 2019, Die Entwicklung des Zahlungsverkehrs im digitalen Zeitalter — eine Zentralbank-Perspektive, Geldmarkt Apéro Swiss National Bank (29 March 2019), page 9, "Diese Technologie könnte zum Beispiel die Grundlage für ein ‚secure Swiss Finance Network' sein. Im Zahlungs-Ökosystem der Schweiz würde damit eine sichere und flexible Kommunikation zwischen Teilnehmern ermöglicht.

the servers of financial institutions.[109] People may need to depend solely on the cash they have in their pockets or stored in some physical location to pay for food and other necessities.[110] Banks may be incapable of providing access to cash at ATMs or in branches if they cannot access their digital ledger, which lists how many digital (sovereign) currencies each customer owns at the bank.[111] Even after electricity and networks are restored, the situation could persist if banks' redundancy (digital) ledgers, and systems were also affected by the attack.

If connected devices are not all rendered useless,[112] novel digital-currency solutions building upon P2P connectivity (e.g., Bluetooth, USB cables) may allow people to continue transferring digital currencies between their smartphones[113] (as means of payment) even without an Internet connection.[114]

109 This is not an imaginary scenario: The World's largest container shipping company, Maersk, saw all its systems and data essentially wiped by a malware called 'NotPetya' in the Summer of 2017. Their IT infrastructure, and therewith their entire operations, were down for almost 10 days. Maersk was arguably only able to recover its systems because one of its servers in Ghana went down shortly before the NotPetya attack and stayed offline. Since all servers were synchronized, Maersk could recover everything from this one server in the middle of Africa.
For an extensive report, see Wired, 2018, The Untold Story of NotPetya, the Most Devastating Cyberattack in History (22 August 2018), "The code that the hackers pushed out was honed to spread automatically, rapidly, and indiscriminately ... 'By the second you saw it, your data center was already gone.' ... NotPetya's ransom messages were only a ruse: The malware's goal was purely destructive. It irreversibly encrypted computers' master boot records, the deep-seated part of a machine that tells it where to find its own operating system. Any ransom payment that victims tried to make was futile. No key even existed to reorder the scrambled noise of their computer's contents ... They had located backups of almost all of Maersk's individual servers, dating from between three and seven days prior to NotPetya's onset. But no one could find a backup for one crucial layer of the company's network: its domain controllers, the servers that function as a detailed map of Maersk's network and set the basic rules that determine which users are allowed access to which systems [without it, nothing was recoverable] ... After a frantic search that entailed calling hundreds of IT admins in data centers around the world, Maersk's desperate administrators finally found one lone surviving domain controller in a remote office — in Ghana. At some point before NotPetya struck, a blackout had knocked the Ghanaian machine offline, and the computer remained disconnected from the network. It thus contained the singular known copy of the company's domain controller data left untouched by the malware — all thanks to a power outage ... When the tense engineers in Maidenhead set up a connection to the Ghana office, however, they found its bandwidth was so thin that it would take days to transmit the several-hundred-gigabyte domain controller backup to the UK ... One staffer from the Ghana office flew to Nigeria to meet another Maersk employee in the airport to hand off the very precious hard drive. That staffer then boarded the six-and-a-half-hour flight to Heathrow, carrying the keystone of Maersk's entire recovery process."
The attack was reportedly performed by Russia: Vice, 2019, NotPetya Ushered In a New Era of Malware (26 April 2019), "It's widely accepted that NotPetya was orchestrated by Russia's military intelligence agency, the GRU. The GRU employs top tier offensive cyber operations and psychological operations teams."

110 This is exactly what happened in the Summer of 2017 in Ukraine, when it was targeted by the 'NotPetya' malware (see also footnote 108). "On a national scale, NotPetya was eating Ukraine's computers alive. It would hit at least four hospitals in Kiev alone, six power companies, two airports, more than 22 Ukrainian banks, ATMs and card payment systems in retailers and transport, and practically every federal agency ... When Derevianko emerged from the restaurant in the early evening, he stopped to refuel his car and found that the gas station's credit card payment system had been taken out by NotPetya too. With no cash in his pockets, he eyed his gas gauge, wondering if he had enough fuel to reach his village. Across the country, Ukrainians were asking themselves similar questions: whether they had enough money for groceries and gas to last through the blitz, whether they would receive their paychecks and pensions, whether their prescriptions would be filled." (Wired, 2018, The Untold Story of NotPetya, the Most Devastating Cyberattack in History, 22 August 2018),

111 Banks may, of course, give out cash as loans.

112 Cyberattackers may block these devices, wipe them clean, or completely destroy them.

113 Ambient-energy harvesting makes these devices not reliant on third-party energy production.

114 Such a solution would need to function in the absence of access to or of existence of a digital ledger, registering who owns how much digital currency. This resilient digital currency will need to ensure that transferring the digital currency to another device is irreversibly logged onto the sender's device in order to prevent the same digital currency from being reused. This will most likely require that the resilient digital currency is linked to a device in such a way that losing the device also means losing all the digital currency stored on the device. If so, then people are likely to hold only a fraction of their digital currency in the form of 'resilient digital currency' (in a similar fashion to how they might hold cash as backup means of payment for such blackout and Internet-connectivity-interruption events, see the text surrounding footnote 54). Furthermore, people are likely to store 'resilient digital currency' on different devices to diversify this risk of loss — for example storing it on a USB drive in a physical vault at the bank.

Digital Currency Is the New Cash

Likelihood of occurrence: Medium

Abstract: Cash holdings drop 80% because cash is no longer viewed as a safer store of value than digital money/assets; in our most likely scenario, cash holdings fall 40-60% because cash continues to be viewed as a safer store of value.

Early-detection signals: leaps in cybersecurity, increase in share of wealth invested in nonmonetary assets, increase in the number of digital vaults people hold, prolonged period without financial crises, excessive trust in new regulations and government interventions, accounts at central bank for everyone.

Context[115]

Cash holdings have dropped by 80%. Digital means have not only replaced cash as the dominant 'means of payment', but **digital money/assets have also largely displaced cash as a safe 'store of value'.[116]**

Sharp reduction in people's security concerns (theft) and privacy concerns (data breaches) relating to digital stores of value (digital vaults and wallets). People have come to view digital infrastructure and digital vaults as highly secure against unauthorized access.

Sharp reduction in people's security concerns (loss due to bankruptcy risks) relating to digital currency held at commercial banks. People may no longer be concerned about bankruptcy of their digital-vault operator for several reasons:

- People may increasingly hold digital nonmonetary assets instead of digital sovereign currencies:[117] These other digital assets (e.g., shares, bonds) are held in segregated accounts and are therefore not lost in case of bankruptcy.
- People may spread their digital sovereign currencies across multiple digital-vault providers (i.e., across different banks), to benefit each time from the deposit insurance ('Einlagensicherung') and to diversify the bankruptcy risk.
- People, especially younger generations, may simply have forgotten about the financial crises that brought banks to the brink of collapse (e.g., the mortgage crisis of 2007). They may no longer be aware of a bankruptcy risk.
- People may believe that bankruptcy of banks is a thing of the past because they expect governments to intervene and save any failing bank, or because they trust new financial regulations to prevent bankruptcies altogether.
- People may have the opportunity to hold their digital currencies directly at central banks.[118]

Government may discourage people from holding cash. Governments may for example discourage people from holding cash as a store of value in order to help central banks better stimulate the economy by enabling CBs to reduce interest rates far below zero.[119]

Governments may discourage people by requiring businesses to set higher prices for goods/services purchased with cash while at the same time depreciating cash relative to the digital currency. An increase in prices for cash payment (similar to a sales tax) combined with a reduction in how much digital currency one unit of cash buys (adjustment of exchange rate) may prevent people from switching from digital currency to cash to avoid negative interest rates.

---

115 We encourage the reader to first read Section 'Ib. Store of value' in our most likely scenario because this alternative scenario focuses on the deviations from the most likely scenario.

116 The shift from physical to digital means of payment is already captured by our most likely scenario, see Section 'Ic. Payment'. Cash, however, remains a very important 'store of value' in our most likely scenario, see Section 'Ib. Store of value'.

117 The most likely scenario makes the point that people increasingly substitute 'digital money' for 'nonmonetary digital assets' as a digital store of value. See Section 'Ic. Payment'.

118 This is captured by the alternative scenario 'Rise of the Central Bank Digital Currency'.

119 Suggesting that governments consider such a policy: Ruchir Agrawal, Miles Kimball, 2019, Enabling Deep Negative Rates to Fight Recessions: A Guide, IMF Working Paper 19/84 (29 April 2019), "enable deep negative rates whenever needed — thus maintaining the power of monetary policy in the future to end recessions within a short time."

Nonetheless, people continue to hold some cash. People's concerns over security, privacy, and bankruptcy risks relating to digital currency may have reduced — but they have not disappeared.[120] Furthermore, cash may continue to be used as a means of payment by the non-digitally inclined and by digitally-savvy people for self-regulation, for its tangibility, for teaching the value of money, and/or out of security and privacy concerns).[121] Finally, people may continue to hold some cash as a back-up means of payment for blackout and network-interruption events.[122]

Rationale for 'Medium Probability' Assessment

We view the probability of such a scenario to be medium for the following reasons:

- Massive investments are flowing into cybersecurity, led by the big cloud infrastructure providers.
- Substantial advances in secure and privacy-preserving data communication infrastructure are likely.[123]
- People are likely to hold/invest an increasingly large share of their wealth in nonmonetary assets.[124]
- People can readily set up digital vaults at different custodians, due to widely accepted digital identities, thus substantially reducing counterparty (bankruptcy) risk. They can seamlessly manage the different vaults through one-stop aggregation digital wallets.
- In a persistent negative-interest environment, central banks may need the flexibility to reduce their interest rates even further into the negatives.

Money Infrastructure

Investors continue to put pressure on banks to improve their efficiency generally. The drastic fall in cash usage puts **additional pressure on the cash infrastructure to significantly lower costs while still providing geographic coverage:**

- If only a small subset of the population (infrequently) uses cash, then costs must be reduced sharply to continue viably operating the cash infrastructure at a reasonable (non-discriminatory) price for its remaining users.[125]
- If everybody still uses cash, though very infrequently, then the very infrequent usage substantially reduces people's willingness to pay for the infrastructure. ***If they view the price as too high, then the banks' reputation and bottom line may suffer as a result***. Customers may view banks as not acting in their best interest (low trustworthiness), as not being very innovative, and/or as not being very competent. If banks do not reduce prices, they may lose the customer relationship (loss of brand recognition) to digital UIs provided by companies that are perceived as innovative. Banks may also lose additional business (e.g., in advisory) to players that are perceived as more competent and trustworthy. ***Banks are therefore likely to be very active in reducing the operational costs of the cash infrastructure***.

No national bank, not even the big ones, has a large enough customer base to operate a proprietary cash infrastructure at sufficiently low prices. **The provision of the entire national cash infrastructure must therefore be delegated to a single operator (utility).**

Even with a single operator, novel solutions are likely needed for sufficient efficiency gains to viably run this physical infrastructure at low enough costs and prices — while still providing full geographic coverage. Crowd-sourcing the cash infrastructure, by making everyone an integral element of it, is likely to be part of the solution.[126]

120 Note that the bankruptcy risk of commercial banks could be eliminated if people have the possibility to hold a bank account at the central bank (see footnote 117).

121 See the discussion on 'Cash continues to retreat as a 'medium of exchange'' in Section 'Ic. Payment' of our most likely scenario.

122 See also the discussion on 'Secure and privacy-preserving communication pipes' in Section 'IIc. Underlying technology' of our most likely scenario.

123 See footnote 107 and the text preceding it.

124 See Section 'Ib. Store of value' in the most likely scenario.

125 This development is similar to what is happening in rural areas in our most likely scenario, see Section 'IIa. CashIIa. Cash'.

126 See the discussion 'Everybody is part of the cash infrastructure' in Section 'IIa. Cash' of the most likely scenario.

Rise of the Central Bank Digital Currency

Likelihood of occurrence: Medium-Low

Abstract: Anyone can have a CB account; in our most likely scenario only depository institutions can have CB accounts.

Early-detection signals: fear of dominance by nonsovereign digital currencies, expanding cashless economy, successful small-scale experiments, gradual expansion of access to CB accounts, reduction of license requirements for CB accounts.

Context

Anyone can have a bank account at the central bank (CB). Put differently, anyone can hold digital currency issued by the central bank — referred to as 'central bank digital currency' (CBDC).[127]

People can choose where to hold their digital currencies, in an account with the CB and/or a commercial bank. People may continue to use commercial banks to hold their digital currency and assume the counterparty risk in exchange for a higher interest on their deposits. **People using the CB as a digital vault (e.g., as bank account) can use third-party digital wallets** to serve as an interface to access and control the digital currencies held in the vault.

Note that **offering accounts at central banks does not stop the 'fractional reserve system' for commercial banks**; these banks can continue to lend up to a certain fraction of the deposits (hence the 'counterparty risk').[128]

Possible paths to CB accounts (non-exhaustive)

CBs may start offering accounts to all for several reasons. **To prevent a nonsovereign currency from becoming dominant and destabilizing financial and economic markets**. Since the Libra coin announcement,[129] fear of a big tech company issuing a digital currency that becomes dominant has increased substantially.[130] CBs might believe that offering CBDC could reduce the likelihood of people switching to nonsovereign currencies.

CBs might believe that we are at the dawn of a cashless society.[131] They may start offering CB accounts in preparation for, or in the event of, a cashless society to **ensure that they can provide access for anyone to 'central bank money'** in any future scenario.[132]

CBs might believe that offering accounts as an alternative to commercial bank accounts **increases system efficiency by forcing commercial banks to properly compensate depositors for counterparty risk** (i.e., bankruptcy risk of losing their deposits). [133]

---

127 Before, only depository institutions could hold (digital) accounts at the central bank. The general public could therefore only hold sovereign currency in the form of physical coins and banknotes (i.e., cash), but not in its digital form.

128 In other words, commercial banks would still be able to create deposits through lending.

129 Libra Association, 2019, An Introduction to Libra: White Paper (8 June 2019).

130 The BIS is for instance warry of such a possibility: BIS, 2019, Annual Economic Report (30 June 2019), page 73, "a big tech could be small in financial services and yet rapidly establish a dominant position by leveraging its vast network of users and associated network effects".

131 See alternative scenario 'A Cashless World Is Born'.

132 Aleksander Berentsen, Fabian Schär, 2018, The Case for Central Bank Electronic Money and the Non-case for Central Bank Cryptocurrencies, Federal Reserve Bank of St. Louis Review 100(2), 97-106, page 101, "If the use of cash is restricted for political reasons or vanishes because of technological innovations, the somewhat strange situation arises that households and firms have no access to legal tender … If cash disappears, the population is forced to make all payments with private money. By offering transaction accounts, central banks enable the general public to hold legal tender in electronic form."

133 Arguing so: Jonathan Chiu et al, 2019, Central Bank Digital Currency and Banking (8 February 2019), Available at SSRN, "We identify a new channel through which CBDC can improve the efficiency of bank intermediation and increase lending and aggregate output even if its usage is low, i.e., CBDC serves as an outside option for households, thus limiting bank's market power in the deposit market."
Aleksander Berentsen, Fabian Schär, 2018, The Case for Central Bank Electronic Money and the Non-case for Central Bank Cryptocurrencies, Federal Reserve Bank of St. Louis Review 100(2), 97-106, page 101, "To attract deposits, they would need to alter their business model or to increase interest rate payments on deposits to compensate users for the additional risk they assume."

Rationale for 'Medium-Low Probability' Assessment
We view the probability of such a scenario to be medium-low for the following reasons:

- There are concerns that CBDC could destabilize the financial sector in general, and lending in particular.[134] CBDC is untested and may lead to unforeseen (second-order) consequences.
- Banks may successfully lobby to avoid CBDC (for some time).
- Multiple central banks have engaged with CBDC, but only a small number expect to issue a CBDC in the medium term (up to six years).[135]

Nonetheless, we believe this scenario to be 'medium-low' and not 'low' because even Mr Agustín Carstens, who heads the Bank of International Settlements (the central bankers' bank), has recently changed his mind[136] and now thinks that CBDC may come "sooner than we think."[137] China, for instance, is reportedly planning on launching a CBDC in late 2019.[138]

Money Infrastructure

CBs may operate their own digital ledger (CB-account infrastructure) and/or rely on digital ledgers by third parties.[139] Where CBs operate their own digital ledger, they may still outsource the building and operation of the infrastructure to a third party.

Where CBs build on third-party ledgers, they act as any other participant, issuing their digital asset/currency on the ledger — such issuing is identical to 'initial coin offerings' (ICOs) on permissionless distributed ledgers. Notable examples of third-party ledgers are SIX Digital Exchange (SDX), Libra ledger, and Bitcoin blockchain.

The usage of cash may decline. Recall that CB accounts are not mandatory: Privacy concerns (giving too much data to the government) and/or fears of negative interest rates on CB accounts do not therefore increase cash usage since people can continue to store their digital money at banks. **People held cash out of security concerns (loss due to bankruptcy risks) relating to digital money held at commercial banks. This concern now disappears**, as people have the alternative of holding their digital money directly at the CB. Whether this reduces the usage of cash is, however, not clear: People may refrain from abandoning cash for CB accounts out of the aforementioned privacy and negative interest rates concerns.

---

134 Among others expressing such doubts are: the Thomas Jordan, Chairmain of the Swiss National Bank (Thomas J. Jordan, 2018, How money is created by the central bank and the banking system, SNB 16 January 2018; NZZ, 2019, SNB-Präsident Thomas Jordan warnt: Libra könnte die Wirksamkeit der Schweizer Geldpolitik beeinträchtigen, 5 September 2019); and Agustín Carstens, General Manager of the Bank of International Settlements (Agustín Carstens, 2019, Ideen zur Zukunft des Geldes, Frankfurter Allgemeine 14 June 2019, "Man entledigt sich nicht eines alten Systems, bevor man nicht weiß, wie das neue unter allen erdenklichen Umständen funktioniert").

135 70% of 63 sampled central banks (covering 80% of the world population) are exploring/experimenting with CBDC but only a few see themselves as likely to issue a CBDC in the medium term; see Christian Barontini, Henry Holden, 2019, Proceeding with caution – a survey on central bank digital currency, BIS Papers N. 101 (January 2019).

136 His earlier position is captured in footnote 133 and the text preceding it. His change in opinion arguably followed the announcement of Facebook's Libra coin (see the text surrounding footnote 140 for a description of the Libra coin).

137 Financial Times, 2019, Central bank plans to create digital currencies receive backing (30 June 2019), "'Many central banks are working on it; we are working on it, supporting them,' Mr Carstens told the Financial Times. 'And it might be that it is sooner than we think that there is a market and we need to be able to provide central bank digital currencies.'"

138 See e.g., Blockchain, 2019, China is about to launch its own digital currency. Here's what we know so far, MIT Technology Review (13 September 2019).

139 For our discussion, it is immaterial whether these ledgers operate as central ledgers, permissioned distributed ledgers, or permissionless distributed ledgers.

Central Banks Are Dead, Long Live Central Banks!

Likelihood of occurrence: Medium-Low

Abstract: New centrally issued currencies are the new money, new currencies and issuers replace sovereign currencies respectively states' central banks; in our most likely scenario, states' centrally issued sovereign currencies continue to amount to money and states' central banks retain their central position (e.g., CHF and SNB, EURO, and ECB).

Early-detection signals: Passivity of sovereign states, loss of trust in state's central Banks, high transaction fees, lack of access, low convenience of sovereign currencies, platform operators viewing themselves as states and/or above states.

Context

The central banks we all know — those created by sovereign states such as the Swiss National Bank, the US Federal Reserve, or the European Central Bank — **first became irrelevant and then disappeared**. Sovereign currencies such as the Swiss Franc or the US Dollar have become relics of the past, found only in museums alongside gold coins and cowry shells.

Nonsovereign currencies have become dominant. Currencies issued by new players have become the dominant form of money. These currencies are not pegged to some sovereign currency (or basket thereof), but are under the full control of their issuers: **The issuers of those currencies are the new central banks.**

Possible Paths to New Central Banks

Different paths may lead to new players replacing states' central banks.

People may adopt a new currency out of convenience, hipster status, fun, or a shift in trust to new digital players **(bottom-up adoption).**

Digital platform operators may not allow the usage of currencies other than their own inside their digital ecospheres **(top-down imposition)**. Imagine Facebook providing its two billion Messenger and Whatsapp users with seamless access and usage in its digital ecosphere only to its Libra coin (see below).[140]

Possible Candidates

In the following, we attempt to provide a sense of the many different places from where new dominant currencies could emerge. The specific currencies and issuers serve only as examples to help the reader by making it more concrete — none of these currencies may become dominant.

Libra coin: digital platform operator. The Libra coin (aka 'Facebook coin') has been introduced as a currency pegged to a basket of sovereign currency (100% coverage). With Facebook in the driving seat, the Libra coin has a potential customer base of over two billion people around the world. Facebook will make usage of the Libra coin as seamless as possible within and outside its digital ecosphere via its digital wallet 'Calibra'. If people broadly adopt the Libra coin and perceive it as a trustworthy currency, the Libra Association may decide to do away with the full coverage and become a central bank of its own.[141] Such a move would be reminiscent of the second half of the 20th century, when states' central banks scrapped the convertibility of their currencies into gold.

QQ coin: digital platform operator. Tencent launched the QQ coin in 2005 for payment in its digital ecosphere boasting over 200 million users. Only the QQ coin could be used to buy virtual goods in Tencent's digital sphere, similarly to how only coins were accepted by arcade video games in the late 20th century. The coin could, for instance, be used to pay for video games, in-game objects, virtual pets, and ringtones.[142]

---

140 T3n, 2019, Facebook Libra: Dagobert Zuck (4. Quartal 2019), "hätten plötzlich hundert Million Menschen über Nacht eine Wallet auf ihrem Smartphone installiert".

141 This seems indeed to be in the back of the minds of the Libra creators: "This approach is similar to how other currencies were introduced in the past: to help instill trust in a new currency and gain widespread adoption during its infancy, it was guaranteed that a country's notes could be traded in for real assets, such as gold." (Libra Association, 2019, An Introduction to Libra: White Paper, 8 June 2019, page 7). Interpreting this passage similarly: Avenir Suisse, 2019, Libra, das globale Finanzsystem und die Schweiz (24 July 2019), page 6.

142 See footnote 144 for more details on QQ coin's rapid adoption and spread beyond Tencent's digital sphere.

M-Pesa: mobile phone network operator. Safaricom, one of Kenya's largest mobile phone companies, started positioning 'pre-paid credits' (aka Airtime credit, Cell credits, mobile phone minutes) as digital currency — called M-Pesa — in 2007. Users of Safaricom could transfer Airtime credits between each other, use it to pay for goods and services, and exchange it for sovereign currency at Airtime merchants across the country. M-Pesa's adoption was driven by solving an important unserved need of the many unbanked people in Kenya: Sending money to their relatives/families living on the other side of the country. In 2013, a staggering 43 percent of Kenya's GDP flowed through M-Pesa, with over 237 million person-to-person transactions.[143]

V-Buck: video game operator. The provider of the popular video game Fortnite, played by over 250 million people in 2019, issues a digital currency 'V-Bucks' that is necessary to buy in-game objects (e.g., skins, character models). Although Fortnite started out as a place to hang out, experiment, and fool around, it could well evolve into a virtual place where business is conducted.

WIR: financial institution. The WIR Bank has been issuing an alternative currency in Switzerland since the first half of the 20th century.

Rationale for 'Medium-Low Probability' Assessment
We view the probability of such a scenario to be medium-low because **it is likely that governments will try to prevent the rise of such a nonsovereign digital currency**. The recent uproar in the aftermath of the Libra coin announcement by policy-makers and central bankers around the world suggests that states will indeed not remain idle on the sidelines.[144] The Chinese government's crackdown on the growing adoption of Tencent's digital currency 'QQ coin' in the late 2000s also supports our view that states are unlikely to remain passive.[145] Governments are likely to curb a rising nonsovereign digital currency because:

- It could destabilize the financial system and the economy (systemic risk).[146]
- It could make it easier for criminals to circumvent laws and regulations.
- It could lead to these private issuers becoming very powerful, raising the risks of anti-competitive behaviors (market power abuses).
- It could lead to these private issuers becoming too-big-to-fail (TBTF).
- It would render ineffective a key policy lever of states (read: monetary policy) for stabilizing prices and supporting economic development.[147]
- Some governments might simply act to defend their threatened position of power.

The Libra scare substantially increased governments' awareness, vigilance, and monitoring of new possibly disrupting currencies issued by large digital platform operators. Nonetheless, **such a new currency can take root in the most unlikely places**, designed for a small niche, without apparent world-domination aspi-

143 Forbes, 2015, M-Pesa And The Rise Of The Global Mobile Money Market (12 August 2015).

144 A couple of weeks after the Libra announcement, the Democratic members of the House Financial Services Committee started circulating a draft act which would ban companies primarily offering a digital platform with more than 25bUSD in revenues from issuing digital assets (called 'Keep Big Tech Out of Finance Act'); see e.g., Chain Letter, 2019, US lawmakers want to stop Big Tech from issuing digital currencies, MIT Technology Review (15 July 2019).

145 Tencent launched the QQ coin as far back as 2005. People needed to buy QQ coins to purchase digital goods in Tencent's digital sphere, ranging from weapons in multi-player games, to virtual pets, to ringtones. Online vendors outside of Tencent's digital sphere then started accepting QQ coins from purchasers buying clothes and electronic devices because they were more practical than credit cards. Further, (informal) online currency exchanges appeared, allowing people to trade QQ coins for fiat money.
Adoption and usage grew substantially: China's fastest-growing currency was the QQ coin and not the Yuan. In 2007, the Chinese Central Bank started showing concern that QQ coins could be used for illegal activities (e.g., drug trafficking, gambling, and money laundering). In 2009, a law was finally passed in China stating that virtual currencies could only be used to pay for virtual goods.
See e.g., Wall Street Journal, 2007, QQ: China's New Coin of the Realm? (30 March 2007); Matthew De Silva, 2019, Tencent created QQ Coin long before Facebook's Libra, qz.com (11 July 2019)

146 Among others, the spill-over risks of combining banking and commerce services at the same entity: "The regulatory and systemic risk of combining banking and commerce requires further attention ... Systemic concerns should prevail against the attractions of granting Big Tech companies any banking licences. But we must also balance consumer benefits with opportunities for financial inclusion and innovation, enhanced commerce and the reality that many consumers expect and demand technological integration with banking and commerce platforms." (Kathryn Petralia, Thomas Philippon, Tara Rice, Nicolas Véron, 2019, Banking Disrupted? Financial Intermediation in an Era of Transformational Technology (ICMB: Geneva, CH), page 77).

147 Kathryn Petralia, Thomas Philippon, Tara Rice, Nicolas Véron, 2019, Banking Disrupted? Financial Intermediation in an Era of Transformational Technology (ICMB: Geneva, CH), pages 77-78, "Central bankers raised concerns [in the aftermath of the Libra announcement] regarding the potential impact on the effectiveness of monetary policy and risks to financial stability, as well as longer term implications for the monetary system and the role of the central banks."

rations, and then suddenly scale exponentially. One such unlikely breeding ground could be the game industry (see above). We believe this scenario to be 'medium-low' and not 'low' because **such developments might fly under the radar until it is too late**.

Money Infrastructure

These new players may operate a digital-money infrastructure themselves, but **new players may (partly) rely on existing money infrastructures**.[148] These nonsovereign issuers may look to build upon existing infrastructures for several reasons. First, they may not (yet) have a trustworthy reputation when they first issue their digital currency. They may thus benefit from the infrastructure operator's trustworthy and reliable reputation. Second, building up an infrastructure from scratch takes time (in particular in the case of physical infrastructure).[149] They may thus scale more rapidly by leveraging existing infrastructures. Third, building separate proprietary infrastructure involves substantial fixed costs. They may benefit from economies of scale by partnering. A prerequisite for such collaboration is that the incumbent's infrastructure is state of the art.

Note that these new players may also decide to issue their own physical coins ('cash'). Hence, they are **may also partner with existing cash infrastructure providers** for the same reasons: economies of scale, and scalability.

148 This might explain why Mastercard and Visa were allowed as founding members of the Libra Association.

149 From communication pipes such as payment schemes, to physical infrastructure such as ATMs, wide payment acceptance at merchants, and digital ledger infrastructure (digital vaults, intra-custodian ledgers) to record ownership and transfer of digital currencies.

A Cashless World Is Born

Likelihood of occurrence: Low

Abstract: Cash disappears completely; in our most likely scenario, cash holdings fall 40-60%.

Early-detection signals: continued decrease in cash holdings and usage, persistently high costs of handling cash, increasing adoption of and trust in a digital cash infrastructure, new technology enabling digital means of payments to continue working in blackouts, belief that phasing out cash would prevent illegal activities.

Context

There is no cash flowing through the economy anymore. **The cashless society is finally born.** The only place where cash is still found in economic transactions is as a 'rare collection item', paid for with a digital currency.

Possible Paths to a Cashless World (Non-Exhaustive)
We believe that government enforcement is the most likely, but not the only path to a cashless society.[150]

Governments withdraw cash to increase the effectiveness of central banks' policy levers. Central banks could then more easily impose deep negative interest rates on digital money deposits to further economic activity, by reducing incentives to save in order to increase aggregate consumption/demand.[151]

Governments withdraw cash to reduce criminal activity and tax evasion. Governments may indeed believe that only phasing out large-denomination notes would not be enough. Central banks have consequently recalled all their coins and banknotes. Issuing alternative forms of physical currency is prohibited by law and made a criminal offense.

Rationale for 'Low Probability' Assessment
We view the probability of such a scenario to be low because:[152]

- A cashless society may discriminate against certain groups such as the digitally uninitiated (e.g., elderly) and the unbanked[153] (e.g., the poor). To protect these vulnerable citizens, governments may be prompted to pass laws requiring merchants to continue accepting cash.[154]
- A majority may continue to fear that a blackout or network interruption could cripple digital means of payment. A majority may not believe that 'privacy and security' can be guaranteed in the digital sphere — that 'digital cash' is the thing of fairy tales.[155] A majority may demand cash in certain instances for self-regulation and/or for teaching the value of money. Finally, a majority may also prefer the tangibility of cash.

---

150 Otherwise, everyone would need to overcome their concerns over the security, privacy, (cyberattack and network-interruption) resilience, and bankruptcy risks relating to digital currency; and to no longer exhibit a preference for cash in any circumstance. See alternative scenario 'Digital Currency Is the New Cash' for more details.

151 Ruchir Agrawal, Miles Kimball, 2019, Enabling Deep Negative Rates to Fight Recessions: A Guide, IMF Working Paper 19/84 (29 April 2019).

152 Even in Sweden, where 6 out of 7 payments are digital, only 20% of the population (down from 25% in 2018) would like a future without cash. See e.g., NZZ, 2019, Löst die E-Krone in Schweden das Bargeld ab? (30 August 2019).

153 Note that although the unbanked could get around paying at cashless stores by buying pre-paid cards with cash, they do not have this option in a cashless world. In 2017, the US reportedly had around 8.4 million unbanked households; see FDIC, 2018, 2017 FDIC National Survey of Unbanked and Underbanked Households: Executive Summary (October 2018), page 1.

154 Several cities in the USA have passed, or are considering passing, a 'cash-acceptance requirements' for merchants in order to avoid discriminating against certain segments of the population. Philadelphia became the first major US city to ban cashless stores from 1 July 2019; New Jersey, New York City, Chicago and Washington are all considering similar measures. See e.g., Finextra, 2019, Philadelphia bans cashless stores (8 March 2019).

155 Cyber-threats have increased massively. See the text surrounding footnote 106.
Their digital data was repeatedly stolen. To name just a few: Facebook suffered a data breach of almost 50 million user accounts in 2018 (Wired, 2018, Everything We Know About Facebook's Massive Security Breach, 28 September 2018); Marriott had 500 million guest records stolen, including the guest's name, postal address, phone number, date of birth, gender, email address, and passport number (Financial Times, 2018, Marriott breach potentially exposed data of 500m guests, 30 November 2018).
Their digital data was repeatedly lost. Facebook lost the data from over 50 million of its users. Guardian, 2018, Revealed: 50 million Facebook profiles harvested for Cambridge Analytica in major data breach (17 March 2018).
Their encrypted digital data was repeatedly decrypted. If quantum computing becomes reality, then it may lead to the decryption of every single (stored) message sent over the Internet since 1990. Spies and policemen have reportedly been storing encrypted digital data since the early 2000s, patiently waiting for their encryption to become obsolete; see e.g., Economist, 2018, Future-proofing the internet: Prime Factors (20 October 2018).

- Even if a majority does not believe so, a minority might. If the government (possibly through democratic majority) bans cash on its territory, the minority may find ways to continue using cash or cash equivalents (e.g., cash issued by foreign sovereign states, cigarettes, gold coins, etc.).
- Phasing out large-denomination notes might be viewed as sufficient to curb illegal activities.[156]
- Phasing out cash to reduce illegal activity may become ineffective: Those wanting to circumvent laws and regulations have sufficient alternatives in the form of secure, privacy-preserving digital assets (e.g., cryptocurrencies).[157]

Money Infrastructure

A 'digital cash' infrastructure may take the place of the 'physical cash infrastructure'. This digital infrastructure guarantees the same levels of security and anonymity/privacy as physical cash. **Governments are likely to impose substantial restrictions on the functioning of such infrastructures.** To balance the 'right to privacy' and 'curbing illegal activities', governments may set an upper limit to how much a given person can transfer anonymously per week or month (e.g., 5,000CHF). This would require that the infrastructure uniquely identifies every person, yet guarantees their anonymity, to ensure that the infrastructure can keep track of how much digital cash a person has already transferred even when they hold multiple accounts.

The physical cash infrastructure may, however, not be dismantled entirely: Some of it may be leveraged to increase security and control over digital currencies.

- The ATMs may be used for offline two-factor authentication. It could distribute uniquely identifiable tangible pieces of paper, that can then be linked to some digital currencies. Authentication with this piece of paper is necessary to control these digital currencies.
- The physical banknotes may be used as uniquely identifiable pieces of paper.
- The physical vaults may be used for cold storage. The vaults may keep these uniquely identifiable pieces of paper safe. More generally, the vaults may store any tangible non-digital private keys that are necessary to control some digital assets/currencies.

156 Arguing that phasing out large-denomination notes would curb illegal activity because the overwhelming demand for large-denomination notes comes from criminals: Kenneth S. Rogoff, 2016, The Curse of Cash (Princeton University Press: Princeton, NJ).

157 We believe that those engaging in illegal activity are very likely to shift to these digital assets — we view it as part of the most likely scenario. See footnote 48 and the text surrounding it.

Moneyless Begins

Likelihood of occurrence: Low

Abstract: Money disappears because no asset is widely accepted to fulfill all three functions of money; in our most likely scenario, the sovereign currencies continue to amount to money.

Early-detection signals: Digital representation of assets and of the rights thereto, digital platformification, explosion in digital data, sovereignty of data subjects over their data, advances in automation, robotics, AI; and rising bartering in subsets of the population (e.g., communities, villages).

Context

There is no such thing as 'money' anymore. **No asset in the economy — not even currencies — fulfills the three conditions for it to be classified as 'money':** There is no consensus on an asset as a medium of exchange, store of value, and unit of account.[158] Actually, **people do not even agree on an asset for either medium of exchange, store of value, or unit of account.**

Different people use different assets (or set thereof) as a store of value and as their unit of account. They 'pay' with assets ranging from 'usage rights to their data', to 'usage rights to their apartment', financial instruments they own (e.g., equity or debt securities),[159] and sovereign currencies. Employees can ask to be 'paid' directly in the asset(s) that they prefer as a store of value.

Currencies, whether cash or digital, do not function as 'money' anymore. But **currencies continue to be demanded and traded** because they still function as a medium of exchange, store of value, and/or unit of account for some people.

Money Is Not Necessary as a 'Medium of Exchange'
A barter economy[160] runs efficiently at scale. Society no longer needs to agree on an asset as a 'medium of exchange'. The 'double coincidence of wants' can be solved without a medium of exchange. This development was driven by the digital representation of the rights to all (digital and non-digital) assets,[161] by the advent of digital (matchmaking) platforms, and by technological advances in automation, robotics, and AI.
A barter economy runs as smoothly as an economy exhibiting a consensus on a medium of exchange.

The 'double coincidence of wants' is solved in two ways.

First, the ***likelihood of a direct match is increased***. There is a higher likelihood of a match between your existing assets, and someone owning the asset you are seeking while also wanting one of your assets.

- *Digital rights* increase the number of assets you can offer to pay with.
- *Automation and AI* further increase the number of assets you can offer, by allowing you to create new digital rights on the spot with one click. You can, for example, combine elements of different assets you own,[162] you can create a 'right to your future produce',[163] or you can create a 'future usage right to your apartment during the first week of July'.
- *Digital platforms* increase the number of potential counterparties you can interact with by allowing you to have a global reach, capturing every last bit of the long tail.

Note that most of you were already paying without a 'medium of exchange' for many digital services in the 2010s — you paid with 'usage rights to your data' for services such as Gmail and Facebook.[164]

158 See Chapter 'Definitions' for the definition of money.

159 In the 2011 movie 'In Time' people have been engineered to live only up to a certain age, but can increase their 'time alive' by buying portions of someone else's 'time alive'. In other words, people can sell their 'right to time alive' for other goods and services.

160 A barter economy is a cashless economic system in which services and goods are traded at negotiated rates., NJ).

161 See the most likely scenario of SIX, 2019, 'Future of Financial Information' for a discussion of why we may expect the rights to almost all (digital) assets to be digitally represented.

162 You could sell the rights to the second and third interest payment of a loan you gave to a friend.

163 You want to buy carrots, but the counterparty does not want the tomatoes you produce. The counterparty may, however, want tomatoes sometime during the next year and would therefore be willing to enter a contract giving them the right to a certain quantity of tomatoes throughout the next year.

164 To be very specific: You paid with 'unlimited usage rights to your data'.

Second, ***the likelihood of an indirect match is increased***. When there is no one owning the asset you are seeking who wants any of your assets, an algorithm may find a chain of bilateral transactions, connecting you to the owner of the sought-after asset, such that each of them fulfills the double coincidence of wants.[165] Specialized players may act as intermediaries (market makers) in such chains by always quoting buy and sale prices between different pairs of assets.

Money Is Not Necessary as a 'Store of Value'

People have access to a broad investment universe: The digitalization of rights to assets in combination with digital platforms have given even non-HNWIs easy access to the world's many investable assets (democratization of the investment universe).[166] With all these easily accessible assets, different people have come to prefer **different (baskets) of assets as a 'store of value'**. Some prefer digital rights to gold because it has withstood the test of time, while others continue to hold sovereign currencies out of habit. Still others may start trusting private companies more than state's central banks, and in turn prefer holding equity or digital currencies[167] issued by these private companies.

Money Is Not Necessary as a 'Unit of Account'

The 'price' of any asset can be displayed in real-time in terms of any other asset.[168] Algorithms scout the most liquid pairs of assets to form a *chain of bilateral exchange rates* linking the to-be-priced assets with the to-be-priced-in asset. *Market makers* furthermore provide liquid bilateral exchange rates between different pairs of assets. **Different people have come to rely on different units of account**. Someone spending their nights and days in an online multiplayer video game may start viewing the video game's virtual currency as the natural benchmark. A very wealthy person, who knows they have enough material wealth for the rest of their life, may decide solely based on environmental contribution/impact, and start evaluating everything in those terms. Others might hold all their material wealth in digital rights to gold and therefore evaluate everything in terms of gold. And still others may evaluate everything in terms of how many hours of work it costs them — or how many hours of free time they would have to give up.

Rationale for 'low probability' assessment

We view the probability of such a scenario to be low for the following reasons.

- It is unclear whether a purely barter economy has ever existed. Contrary to received wisdom, there seems to be no evidence that a barter economy preceded money-based economies.[169]
- Switching from a money-based transactional system to a barter economy will demand significant willingness to experiment from people. In increasingly uncertain times marked by increasing speed of change, people are likely to seek constancy elsewhere and to 'stick to what they know' when given the choice.

Money Infrastructure

Money infrastructures continue to be relevant. Although money per se does not exist anymore, **people still hold the physical and digital assets that amounted to money**, and people still exchange those assets. However, **the demand for, and exchanges in, these hitherto-monetary assets falls substantially**. For example, the usage of physical currency ('cash') as a store of value and a medium of exchange falls substantially.

---

165 This is akin to a multi-team trade in the NBA: Team A may want a player from team B, but team B is not interested in a player from team A; team C, however, has a player that team B wants, and team C furthermore wants a player from team A.
Note that this algorithm, among other things, also takes into consideration the distances between the various bilateral parties, the requested settlement dates, the availability of third-party transportation services (logistics), and the expiration dates of the goods and services.

166 See Section 'Ib. Store of value' in the most likely scenario for an overview of some digital assets.

167 See the scenario 'Central Banks Are Dead, Long Live Central Banks!.

168 AR glasses/lenses

169 See e.g., Ilana E. Strauss, 2016, The Myth of the Barter Economy, The Atlantic (26 February 2016), "When barter has appeared [in our history], it wasn't part of a purely barter economy, and money didn't emerge from it—rather, it emerged from money. After Rome fell, for instance, Europeans used barter as a substitute for the Roman currency people had gotten used to ... [the historical data we have only includes cases where barter] 'takes place between people who are familiar with the use of money, but for one reason or another, don't have a lot of it around.'" (citing David Graeber from the London School of Economics). Seminally, Caroline Humphrey, 1985, Barter and Economic Disintegration, MAN New Series 20(1), 48-72.

It's a Bitcoin World

Likelihood of occurrence: Low

Abstract: Decentrally issued digital currencies are the new money; in our most likely scenario states' centrally issued sovereign currencies continue to amount to money.

Early-detection signals: loss of trust in governments, rising trust in code, substantial advances in permissionless distributed ledger technologies (DLTs).[170]

Context

Decentralized digital currencies have become dominant: Crypto-currencies (e.g., Bitcoin, Ether) have **replaced central-bank-issued currencies** as the dominant forms of money. Crypto-assets[171] are the dominant form of digital assets. Crypto-contracts[172] are the dominant form of contracts. **Digital services take the form of open-source** code stored on these permissionless distributed ledgers and decentrally executed by participants to these ledgers —which are known as 'decentralized applications' (**DApps**).

Rationale for 'Low Probability' Assessment
For decentralized digital currencies to become dominant, *several conditions must be fulfilled*. We view the probability of all these conditions being jointly fulfilled to be low. The following will walk you through some of them.

First, ***people must lose trust that governments act in their interest***.[173] They may lose trust because they fear that their private property rights will not be upheld (fear of expropriation), and that their contractual rights will not be enforced.[174] A private (centralized) company cannot take the place of the government: It will not be trustworthy because the government could simply nationalize the company; or if it isn't already, the company might itself become untrustworthy in the future just as the government did.

Second, ***reliance on the jurisdiction of a trusted third-party government must be impractical***. If a third-party government is trustworthy, then a fully decentralized system may not be needed. People may, for example, have bank accounts in Switzerland to securely keep their (digital) assets outside of their government's reach. People may use the US dollar or Swiss franc instead of their local currency as a medium of exchange.

Third, ***people must want to stay in the digital sphere***. This may be because it allows them to deal with foreign service providers, or perhaps because it allows them to subscribe to and instantly consume a digital service such as Netflix. Or, it may simply be because it is more convenient to carry digital money than physical cash. If they don't, then they may, for example, return to using precious metals such as gold as a medium of exchange and/or store of value.

Fourth, ***people must trust the code of permissionless distributed ledgers***. Although distributed ledger technologies (DLTs) tend to be advocated as 'trustless', quite a bit of trust is still needed. People must trust that there

170 Permissionless distributed ledgers (e.g., Bitcoin blockchain, Ethereum blockchain) are defined as ledgers wherein anyone can be part of the consensus protocol. See also Cambridge Centre for Alternative Finance, 2018, Distributed Ledger Technology Systems: A Conceptual Framework (August 2018).

171 Crypto-assets are defined as digital assets issued on some permissionless distributed ledger (see footnote 169 for the definition). The ledger serves as the registry for ownership rights to these assets.

172 Crypto-contracts are defined as digital contracts that are (i) written in code and automatically run/execute the code when the conditions in the contract are met (aka 'smart contract'), and (ii) whose code is registered on some permissionless distributed ledger. These contracts are either self-enforcing or decentrally enforced, and thus require no trusted centralized entity for enforcement.

173 A loss of trust in governments' capabilities to orchestrate society and the economy is unlikely to be enough for people to turn to fully decentralized systems. There are too many alternatives that rely on existing structures and ways of doing things. Government incompetence is instead likely to lead people to rely on private parties (e.g., relying on private arbitrators instead of public judges to resolve legal disputes). The incompetence of countries' central banks (e.g., hyper-inflation) is likely to lead people to rely on an alternative centrally issued currency (e.g., WIR, mobile phone credits).

174 They may not only have such beliefs in countries with authoritarian governments, but also in democracies: They may believe that the government is discriminating against them (e.g., elites feeling that governments favor the masses, or vice versa).

are no bugs in the code,[175] that the consensus protocol can scale, that the system remains decentralized,[176] that the system is resilient against cyberattacks,[177] that a fully open-source economic system can work,[178] etc.

Fifth, ***governments must not be able to interfere with these ledgers and their execution***. Governments might be able to overpower the consensus protocol or to prevent Internet access to the ledger (e.g., by monitoring/controlling Internet traffic). And even if they cannot interfere with the ledgers themselves, they may interfere with the execution of the rights and obligations included in crypto-assets: The execution of crypto-assets may not be automatic, but require a real-world person to take an action, and the execution may be linked to a non-digital asset such as a car or a piece of art. A government may thus be able to throw this person in jail, confiscate the car, or intercept the piece of art when it is shipped to its new owner.

If so, then people *may* adopt decentralized digital currencies as money.

Money Infrastructure

Digital assets, including crypto-currencies, are registered on these permissionless distributed ledgers. Hence, **the permissionless distributed ledgers amount to the underlying infrastructure for securely storing and transferring digital money.**

Permissionless distributed ledgers include a native digital wallet and communication platform for participants to interact. Nonetheless, **third-party digital UIs/apps (e.g., digital wallets) and payment may be built and run on top of these ledgers — as DApps**. Indeed, communication interfaces may be embedded in third-party apps (embedded finance), and participants may demand higher privacy/security than offered by the built-in native communication platform.

Cash may continue to exist even if people do not trust a (centralized) entity to issue it.[179] **If real-world objects are uniquely identifiable**, they can be uniquely linked on the distributed ledger to a given crypto-currency coin. Think of a famous painting, say the Mona Lisa. If there is an image-recognition application (running as a DApp) that can with absolute certainty detect a fake, then unique identifiability is given. The Mona Lisa could then be linked on the ledger to a specific crypto-currency coin so that a transfer of that coin always necessitates a positive identification by the image-recognition DApp of the Mona Lisa. **The one possessing the real-world object has full control over the linked crypto-currency coin**.[180] Cash in this world can help as a 'store of value' since the Mona Lisa can be stored in a physical vault. Instead of a Mona Lisa, the same can be done with anything, perhaps even a simple piece of paper on which you drew something (we might call such pieces of paper 'crypto-notes').

175 It has been reported that 1,000 lines of code exhibit on average 15–20 bugs. "[G]ood programmers working under careful supervision average about one bug per 2,000 lines of code." (Economist, 2019, Cyber Security: Hack The Plant, 14 September 2019).

176 It has, for example, been reported that the most famous permissionless distributed ledger, the Bitcoin blockchain, is no longer really decentralized: 60% of the computing power in the Bitcoin blockchain resides in China. Recall that one controls the Bitcoin blockchain (since its consensus protocol is proof-of-work) if one owns 50% or more of the entire computing power in the system. For the data, see Bryan Ford, 2018, Clubs, Coins, and Crowds: Fairness and Decentralization in Blockchains and Cryptocurrencies, Presentation at IEEE Security & Privacy on the Blockchain (23 April 2018).

177 Cyberattackers might otherwise steal the crypto-assets registered thereon.

178 Any participant must be able to verify all the codes for the system to remain trustless, which requires that all code be open source. An incentive model is therefore needed to reward those developing new code since anyone can readily copy the code once it is published in the system — such an incentive model must be built directly into the system's core code base.

179 People would need to trust that the 'issuing entity' does not produce the same banknote twice (i.e., the same serial number twice).

180 This is identical to: The one knowing the private key has full control over the crypto-currency coin.

3 Definitions

In the following, we provide our definitions of the concepts found throughout this paper. We have tried to follow the most-widely accepted definitions.

Money: describes any physical or digital asset for which there is wide consensus that it jointly exhibits the following three characteristics — there is wide consensus that it jointly serves the following three functions:[181]

- **Medium of exchange:** it is commonly used (accepted) as a means of payment for goods and services
- **Store of value:** it is commonly used to save wealth across time, to postpone consumption of goods and services
- **Unit of account:** it is commonly used by people to measure the (relative) value of goods and services

Nonmonetary assets: (digital) assets which do not amount to money; namely, assets which are not generally accepted/perceived as money (i.e., as not jointly fulfilling the three functions of money). In the mid-2010s such assets included among others: diamonds, equities, bonds, flyer miles, fine art, collectibles, Bitcoin, V-Buck.

Digital assets: describe 'something' that can be owned and has a digital presence. Digital assets are a subset of *intangible assets (Immaterialgüter)*.

- We distinguish between two types: ***digitized digital assets***, which capture digital representations of tangible and intangible non-digital assets/things, and ***native digital assets***, which have no existence in the non-digital realm.
- Digital assets take many different forms. The following list is probably not exhaustive: *digitally recorded knowledge* (e.g., digital documents, books, websites, media, news, trade secrets, patents); *digitally recorded non-digital raw data* (e.g., digital representations of mountains, trees, houses, people); *derived digital data*[182] (e.g., calibrated/trained analytics and matching algorithms, results from statistical queries, interpretation of regulatory data, news data, calculated prices for illiquid assets, rating data); digital behavioral data (e.g., social media data, trading data on digital trading venues, clicks and website visits, digital payment data); *software in the form of code* (e.g., analytic algorithms, optimization algorithms, video games); *digital art* (e.g., digital photographs, movies, music); *digital properties* (e.g., virtual in-game objects, virtual pets, virtual luxury goods, native crypto-assets); *digital currencies* (e.g., bank money, central bank digital currency, Libra, crypto-currencies).
- Digital assets issued on a distributed ledger can be referred to as *tokens*. Digital assets issued on a distributed ledger and representing some underlying assets (e.g., equity shares, art, real estate) can be referred to as *tokenized assets*. Digital assets issued on a permissionless distributed ledger can be referred to as *crypto-assets, crypto-coins,* or *crypto-tokens*.
- **Rights to (digital) assets** are also a subset of intangible assets (i.e., *digital rights themselves amount to digital assets*). The rights to digital assets — from ownership rights (intellectual property), to usage rights — are a key source of value creation in the digital and intangible economy.[183]

Currency: describes an asset that has been created/issued with the primary purpose of serving as a 'medium of exchange' (i.e., as 'means of payment'). It may take the form of ***physical currency*** (e.g., cash, coins, banknotes, gold coins) or ***digital currency*** (e.g., e-money, QQ coins, Bitcoin, Libra).[184]

- **State currency** (sovereign currency, public currency, öffentliches Geld): describes a currency issued by a sovereign state, typically via the state's central bank.
- **Central-bank-issued currency** (CB-issued currency): describes the currency issued by a central bank. States' central banks[185] have historically only issued coins and banknotes (i.e., cash) to the public, and only issued digital currency to depository institutions (e.g., banks).
- **Central bank digital currency** ('CBDC'): describes digital currency issued by central banks to the public. There

181 We are aware that economists still disagree about the definition of money. We follow the three-function definition of most modern economic textbooks. See e.g., N. Gregory Mankiw, 2018, Macroeconomics (Worth Publishers: New York, NY. 10th edition).

182 Derived data describes new data that has been built on top of existing digital data.

183 Rights to digital assets should therefore be recorded on financial statements and income statements to represent economic realities.

184 In everyday usage, 'currency' is used to refer to 'state/sovereign currency'. We differentiate between other forms of currency.

185 Central banks created by sovereign states such as the Swiss National Bank, the US Federal Reserve, or the European Central Bank.

are two ways this can be implemented in practice.[186] First, through people having accounts directly with the central bank. Second, through people being participants on some digital ledger[187] to which the central bank is itself a participant[188] and on which the central bank issues its digital currency — this CBDC may be referred to as 'tokenized sovereign currency/money'.

- **e-currency** (e-money): describes a digital currency that is denominated in, and pegged to, a sovereign currency, with the promise of being fully redeemable at face value[189] in this sovereign currency.[190] The qualification of a digital currency as 'e-currency' is material because it may bring about certain regulatory requirements.[191] It includes e.g.: bank currency,[192] stablecoins (that are pegged to and redeemable in sovereign currency).[193]
- **Virtual currency:** describes a digital currency that is not denominated in, or pegged to, and/or redeemable in sovereign currency. It includes among others: Bitcoin, QQ coins, V-Bucks, Libra.[194]
- **Bank currency** (bank money, Giralgeld, Buchgeld): describes the digital currency people hold on digital bank accounts (i.e., in the digital vaults provided by commercial banks).[195] Digital currency in bank accounts does not amount to CB-issued currency: It only gives its owner a right/claim against the bank for an equivalent amount of physical CB-issued currency (i.e., coins and banknotes). We can think of this 'right/claim' as an 'IOU coins or banknotes' issued by the bank. Bank currency therefore amounts to a private digital currency that is pegged to the CB-issued currency — namely, it amounts to an e-currency.[196]
- **Lead currency** (reserve currency, anchor currency, Leitwährung, Ankerwährung): describes a currency held in high quantities by governments and institutions as foreign exchange reserves. A currency commonly used in the global economy such as in international transactions and investments (payments respectively investments in these contracts denominated in this currency).[197]
- **Pegged currency:** describes a currency whose value is tied to the value of some other asset/currency — where the exchange rate with another asset is fixed. It includes among others: e-currency, stablecoins.
- **Crypto-currency:** describes a digital currency issued on a *permissionless distributed ledger*.[198] We distinguish between two types: *decentralized crypto-currency* whose supply is not under the control of some centralized entity (e.g., Bitcoin, Ether); and *centralized crypto-currency* whose supply is under the control of some centralized entity. ***Stablecoins*** are pegged centralized crypto-currencies, we distinguish between *fully-backed stablecoins* (or 'collateralized stablecoins')[199] and *non-backed stablecoins* ('non-collateralized stablecoins').[200]

---

186 The former has been referred to as 'account-based CBDC' and the latter as 'token-based CBDC', see Tobias Adrian, 2019, Stablecoins, Central Bank Digital Currencies, and Cross-Border Payments: A New Look at the International Monetary System, IMF-Swiss National Bank Conference (14 May 2019).

187 This ledger may be centralized or distributed, permissioned, or permissionless.

188 The Central Bank therefore does not on its own decide/validate which transactions get written (in what order) into the ledger.

189 If someone buys e-currencies for 1 CHF, then they can always exchange those e-currencies back from the issuer for 1 CHF.

190 See e.g., Tobias Adrian, Tommaso Mancini-Griffoli, 2019, The Rise of Digital Money, IMF Fintech Notes (15 July 2019), page 1, "e-money ... electronically stored monetary value denominated in, and pegged to, a common unit of account such as the euro, dollar, or renminbi, or a basket thereof ... while guaranteeing redemptions at face value ... The issuer must be in a position to honor this pledge."

191 See e.g., in the EU the EC Directive on Electronic Money ('E-Money Directive', 2009/110/EC, originally 2000/46/EC).

192 Bank currency is e-currency issued by a 'licensed bank'.

193 One example is the Paxos Standard Token, issued on the Ethereum blockchain and 1-to-1 pegged to and collateralized in USD (held in bank accounts of US banks).

194 The Libra coin is not an e-currency for two reasons. First, it is not pegged to a given sovereign currency because the value of one Libra coin relative to any given sovereign currency can vary (see footnote 202). Second, it is not denominated in a sovereign currency because it has its own unit of account.

195 Bank currency is created in two ways: through people giving physical CB-issued currency (i.e., cash) to the bank, which then credits that person's digital bank account with 'bank currency'; and through banks lending the 'bank currency' that sits in its digital bank accounts (referred to as 'fractional reserve system').

196 Agustín Carstens, 2019, Ideen zur Zukunft des Geldes, Frankfurter Allgemeine (14 June 2019), „Aber Geld ist nicht gleich Geld. Bargeld ist öffentliches Geld, das von der Zentralbank ausgegeben wird. Wenn jedoch Einkäufe mit Kredit- oder Debitkarte getätigt werden oder, was immer häufiger geschieht, mit dem Handy, dann wird privates Geld verwendet. Dabei handelt es sich um Verbindlichkeiten einer Geschäftsbank".

197 The UK pound sterling was the lead currency for most of the world in the 19th century (i.e., 'global lead currency'), and the US dollar was arguably the lead currency of the second half of the 20th century (which has been referred to as 'dollarization').

198 Its name references the cryptography that is at the core (consensus protocol) of the first arguably functioning permissionless distributed ledgers, the Bitcoin blockchain. The consensus protocol ('proof of work') required participants to solve a cryptographic puzzle and the winner is elected as consensus leader for the 'next block'.

199 They amount to e-currency when they are backed by sovereign currencies.

200 An algorithm is supposed to mechanically maintain the peg.

Digital vault: describes a digital ledger database in which (digital) asset ownership is digitally registered/recorded.[201] The best-known examples are the *digital bank account*, which records ownership of physical CB-issued currencies,[202] and the *digital securities account* (Wertschriftendepotkonto), which records ownership of financial securities.

- The provider of a digital vault may additionally provide a *physical vault* for safekeeping of real-world tangible assets, which may underlie 'digitized assets' that are stored in the 'digital vault'.
- The provider of a vault is referred to as the ***custodian***. The (digital) assets are said to be under/in custody of the provider.

Digital wallet: describes a *digital service (e.g., website, app, AR, voice interface)* displaying an overview of, and providing control over, one's (digital) assets held in a digital vault (e.g., digital bank account). So-called 'aggregation wallets' provide an overview across multiple digital vaults.

Libra: describes Facebook's attempted foray into payment. The key is to understand that there is a significant difference between Libra ledger, Libra coin, and Calibra.

- The ***Libra ledger*** is the underlying infrastructure on which the Libra coin is registered; the ledger describes who owns which Libra coins. Importantly, the Libra ledger could be extended from the Libra coin to registering ownership of any digital asset.
- Although it tends to be referred to as the 'Facebook coin', the Libra coin is the digital currency issued by the Libra Association. The ***Libra coin*** is stated to be pegged to and fully-collateralized in a basket of sovereign currencies.[203] The issuance of the Libra coin always takes place on the Libra ledger.
- ***Calibra*** is the digital wallet operated by Facebook; it is connected to the Libra ledger and provides overview, access, and control over one's Libra coins. Other players can also set up their own digital wallets and connect them to the Libra ledger.

---

201 If the digital ledger database is hacked or destroyed, people may lose ownership to their digital rights. The digital ledger database is the 'single source of truth' for the ownership to these digital rights. Backups and immutable transaction logs may alleviate the destruction risk. And public-key cryptographic signatures provided by third parties may alleviate the hacking risk.

202 To be specific, it records the ownership of a digitized asset — of the 'right to a certain amount of physical CB-issued currencies'.

203 "[This] portfolio composition ... would expose them [consumers and businesses] to excessive exchange rate risk ... Even if the circulating Libras were always fully backed, their exchange rate relative to national currencies thus would fluctuate, exposing users to unwarranted risks" (Dirk Niepelt, 2019, Libra paves the way for central bank digital currency, VOX CEPR Policy Portal, 12 September 2019).
"[Since it] plans to tie its currency to a pool of assets as a stability mechanism ... Libra is economically akin to a global exchange traded fund (ETF) with transaction services" (Kathryn Petralia, Thomas Philippon, Tara Rice, Nicolas Véron, 2019, Banking Disrupted? Financial Intermediation in an Era of Transformational Technology (ICMB: Geneva, CH), page 37).

Note to the Reader

Authors

The views expressed in this paper are those of the authors, and do not necessary reflect those of SIX or of those having contributed. For more information about this report, please contact the authors.

Dieter Goerdten
Head Products & Solutions, SIX
Dieter.Goerdten@six-group.com

Dr. Alexander Verbeck
Head Cash Ecosystem, SIX
Alexander.Verbeck@six-group.com

Dr. Tobias Lehmann
Future Scenarios Lead, SIX
Tobias.Lehmann@six-group.com

Daniel Steingruber
Innovation Field Products & Platforms Lead, SIX
Daniel.Steingruber@six-group.com

Acknowledgments

The authors would like to thank the many colleagues for their contributions via discussions, interviews, document reviews, and workshop participation. They would especially like to acknowledge the contribution of the following industry experts.

Stefan Baumberger
Leiter Strategie Bilanz- und Geldverkehrsgeschäft, ZKB

Marino Caprini
Head Cards, Cash & Commission Solutions, Credit Suisse

Nicolas Cramer
Head Card & Payment Solutions, UBS Switzerland AG

Cornelius Dorn
Head Strategy and Business Development, SIX

Andrej Eichler
Chief Market Officer FS, Worldline

Jörg Engelhart
Leiter Bancomaten Services, Entris Banking

Pascal Egger
Product Manager, SIX

Dr. Remo Frey
Senior Open Innovator, SIX

Marcel Gertsch
Head ATM, TWINT & Debit Cards, Credit Suisse

Marc-Alain Giger
Geschäftsführer, NCR (Schweiz) AG

Claudio Gisler
Head Marketing & Products, WIR Bank

Roland Hallauer
Head Physical Cash, UBS Switzerland AG

Marc Hasler
Geschäftsführer, SecurePost AG

Willy Kämpfer
Senior Business Consultant, SecurePost AG

Dr. Olaf Klein
Principal Consultant, Luxoft

Matthias Niklowitz
Industry Analyst and Business Journalist

Lothar Raif
Corporate Account Executive, Post CH AG

Steffen Rossberg
Leiter Geschäftsbereich Bank, Entris Banking

Richard Schlauri
VRP & Geschäftsführer, Diebold Nixdorf (Schweiz) AG

Armin Schmid
CEO, Swiss Crypto Tokens AG

Dr. Andreas Sprock
Head Innovation Management, SIX

Kilian Stillhart
Head of Payment Systems/ATM, Raiffeisen Schweiz

Astrid Utrata
Head Value Creation for Financial Services, SAP

Visualizations: Kilian Wilde (wilde-grafik)
Copyediting: Rob Scott (Robin Scott Translations)

SIX
Pfingstweidstrasse 110
Postfach
CH-8021 Zürich
www.six-group.com