Länsstyrelsen Skåne

Interreg North Sea Region BLING

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EUROPEAN UNION

BLOCKCHAIN - OBSTACLES AND OPPORTUNITIES FOR DEMOCRACY DEVELOPMENT

TRUSTING THE ALGORITHM?

SWECO

EXECUTIVE SUMMARY

Interest in blockchain's potential in the public sector is global and can be seen in the increase in experimentation and the volume of publications on the subject and attention by experts and researchers. On a global level, US and China account for a majority of patent filings and companies among the top 100. On a European level, the UK stands out as the leader in blockchain investment in start-ups, capturing almost 70 % of funding with the Netherlands in a distant second place.

At its core, blockchain enables large groups of individuals or entities, whether collaborators or competitors, to reach consensus on and immutably record this agreed-upon record of the truth permanently without a central authority. Blockchain technology has because of this been referred to as a "trust machine" since it provides an elegant solution to the problem of trust between networks and can enable large number of strangers to complete transactions with each other without risk of being cheated. The principles underpinning blockchain can be summarised as i) wide distribution and redundant, ii) transparency and auditability, iii) immutable and secure and iv) decentralised consensus. Blockchain is best suited for use cases requiring at least three of the principles outlined. If only one or two are required then blockchain may work, there are likely simpler and / or cheaper ways to solve the problem and fails to offer a clear value add compared to centralised systems. The scale and complexity of current public services go beyond current technological blockchain developments.

Blockchain offers new ways of organising public sector services but also demands new ways of governing traditional legacy systems. Benefits often relate to better security (improved data integrity, tamper-resistance), efficiency gains (reduced processing, less time and costs) and a greater level of trust in public records. There are however limited examples of scaled up public sector use of blockchain in democratic processes, especially moving beyond proofs of concept. Estonia is the most cited and advanced example, with a large ecosystem of more around 3000 services (including e-voting). Other examples of blockchain used in elections include Colombia, US state of West Virginia, India, South Korea. Some high-profile use cases have also stalled, such as when the government of Moscow introduced a digital voting system but was found to have critical security flaws. Elections and voting are still largely conducted offline.

The idea of liquid democracy is proposed by some advocates as an elegant solution to the 'democracy deficit' afflicting established democracies. The hope is that by removing power barriers between voters and the elected official and introduce more accountability this would offer a more direct form of democracy. So far, blockchain has offered a set of incremental rather than disruptive innovations, as sometimes portrayed, although some of them can make a significant difference. How impactful blockchain in public sector will be has yet to be seen, as the technology is in its infancy and must overcome several bottlenecks related to scale, performance and confidentiality. Blockchain in public sector is at a defining stage in a rapidly evolving landscape. There are few easy answers to come by and little established expertise on 'what works' in public sector. Trust is a key factor in the adoption, the case for the application of the blockchain to democratic procedures is not yet clear. Although it has the elicited considerable excitement, we are only seeing the start of the different use cases that are attempting to transform and improve democratic processes. The diffusion of blockchain will take time and it is difficult to predict what the next "killer app" for the blockchain will be.

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GLOSSARY

Bitcoin	Type of non-state digital currency in which a record of transactions is maintained, and new units of currency are generated by the computational solution of mathematical problems, and which operates independently of a central bank.
Cryptocurrency	A cryptocurrency is a new form of digital asset based on a network that is distributed across many computers. The word "cryptocurrency" is derived from the encryption techniques which are used to secure the network
Distributed Ledger Technology	A distributed ledger technology (DLT) is a secure and immutable database where pieces of the ledger are stored in various locations along a decentralized network. Often used interchangeable with blockchain.
e-Government	Short for electronic government is provision of electronic services and the process of digitalising these for more convenient access by citizens.
e-voting	Electronic voting is voting that uses electronic means to either aid or take care of casting and counting votes. I-voting (Internet voting) is also used interchangeable with e-voting.
General-purpose technology	Technology that has the potential to drastically alter societies through their impact. Classic examples include the steam engine and electricity.

ABOUT THIS REPORT

This report is commissioned by the County Administrative Board of Skåne, one of 13 partners in the BLING (BLockchain IN Government) project funded by the Interreg North Sea Region Programme 2014 – 2020. The project combines the expertise of knowledge institutions and the playing field of municipalities and governmental organisations together with businesses and citizens, thereby investigating what role blockchain can play for governments.

CREDITS

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PURPOSE AND STRUCTURE OF THE REPORT

This report looks at the ongoing exploration of blockchain technology by the public sector in the light of core theme of democracy. The report serves to map the central themes that are emerging from public discourse and public sector initiatives and give a brief overview of what is currently happening.

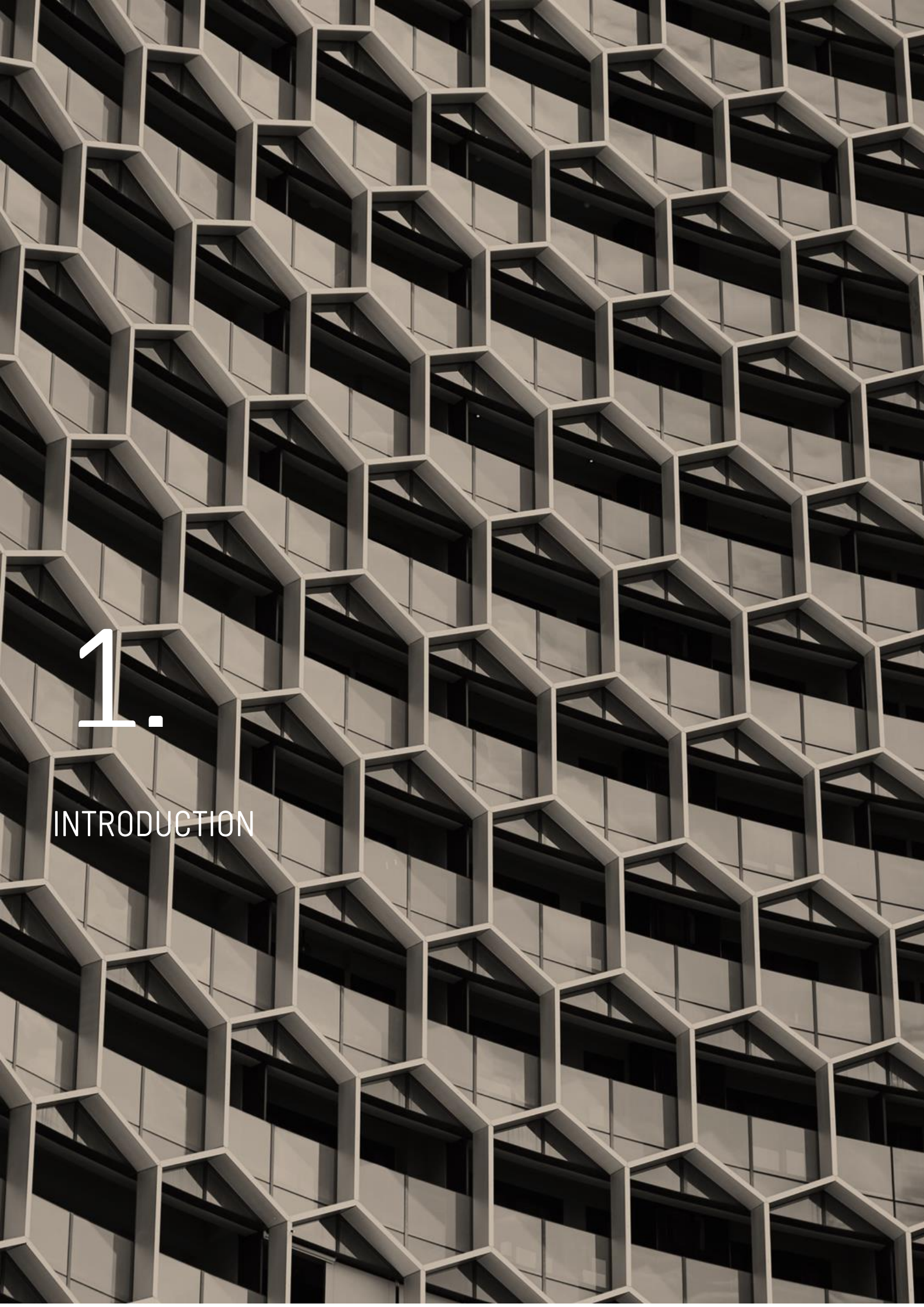
METHODS, SCOPE AND DELIMITATIONS

Our analysis is focused on existing literature related to blockchain. In some circumstances, we also include conference reports or other material available, but the bulk of our data collection efforts have been targeted towards existing literature. The report should therefore be read as a synthesis of available research and literature on democracy and blockchain.

Our focus is on providing an overview of current EU policy and regulation with regards to blockchain technology, summarising the most oft-discussed challenges related to blockchain technology vis-à-vis democracy, and highlighting some of these challenges.

Our analysis is focused on the already existing literature related to blockchain. In some circumstances we also include conference reports or other material available, but the bulk of our data collection efforts have been targeted towards existing literature. We do not attempt to discuss the economic ramifications of Bitcoin or other cryptocurrencies based on blockchain and focus of these reports. Discussion of the technology will only be involved to the degree required for understanding the content.

Given the wealth of publications on the topic these reports are intended as an introduction for non-technical readers. Readers in search of greater precision should consult the sources listed in the additional technical references section.



1.

INTRODUCTION

1. INTRODUCTION

New technology often brings promises of radical change. Blockchain and distributed ledger technology has been highlighted by both experts and researchers as a step-change in how governments can provide service to its citizens. This innovative general-purpose technology offers new ways of organising in many domains and myriad of sectors, everything from finance to health care and education to democratic process including the exchange and transactions between the public and the private.

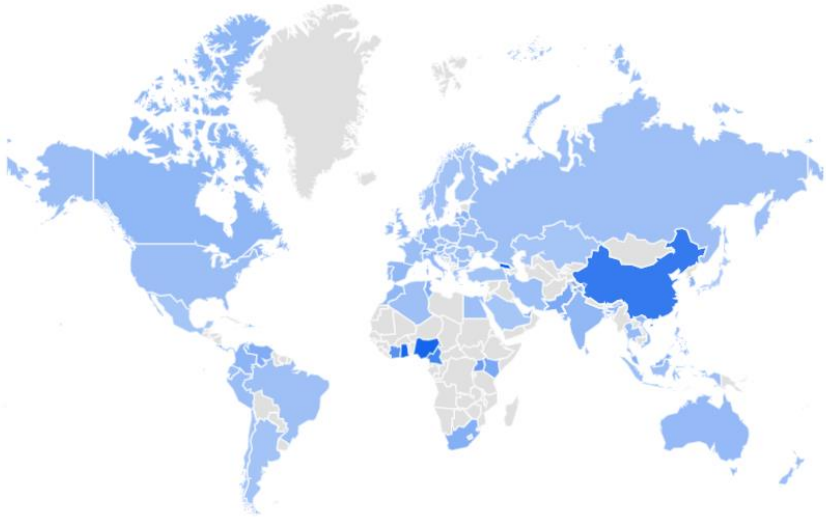
However, the very nature of the technology, the range of actors involved, the still developing technology and the distributed nature raises many questions around the implementation of blockchain applications in public sector that need attention.

Blockchain technologies, that are at the core of cryptocurrencies such as Bitcoin, are presented by advocates as a breakthrough with great potential for the public sector. Governmental organizations need a thorough understanding, the possible applications in the domain of e-government and the exploration of governance mechanisms to deal with the limitations and challenges of the technology. Blockchains emergence and use in public sector also has important implications on citizen trust, privacy, inclusion and participation.

BLOCKCHAIN INTEREST IS GLOBAL

The search volume on Google for words and "Blockchain" can serve as a crude indicator of the interest in this technology in different countries. Europe shows relatively high interest in blockchain, but Nigeria, Ghana and China stand out with the highest search volume with Switzerland as first European country coming on seventh place.

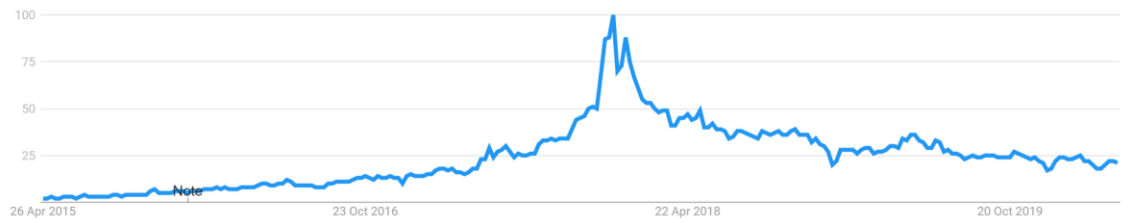
Figure 1: Google Search Volume past 12 Months for Blockchain (March 2019 – March 2020)



Source: https://www.google.com/trends retrieved March 21, 2020
Note: Darkest Blue = Index 100

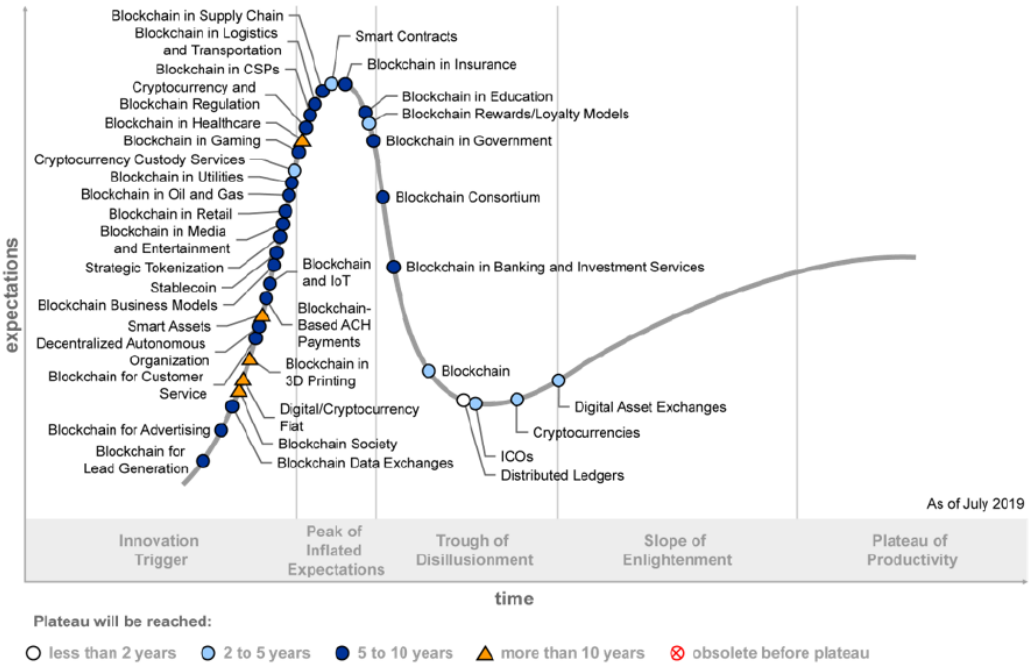
When looking at interest over time for the search term "Blockchain", it had a clear peak in December 2017. Unsurprisingly, this is also when Bitcoin (cryptocurrency based on blockchain technology) reached its peak value at almost 14,000 dollars per bitcoin. As a reference, as of 20th March 2020, one Bitcoin was worth 200 dollars. Bitcoin is not blockchain, however – rather, blockchain is the technology that underpins Bitcoin as its most famous use case.

Figure 2: Google Search interest for Blockchain (last five years)



The latest available Hype Cycle (see figure 3) that is used to assess maturity and adoption of technology from the analyst firm Gartner shows that "Blockchain in Government" has passed the 'peak of inflated expectations'. If following this model, blockchain is now five to ten years from joining the so-called 'plateau of productivity' or mainstream adoption. Although very speculative by nature, the Gartner Hype Cycle – which is based on a survey to business leaders – suggests that there are several use cases for blockchain that are leaving the 'trough of disillusionment'. If search interest (as seen in figure 1) could be taken as an indication on where inflated expectations exist, blockchain could in that case be said to have passed the peak. As seen in the figure below, cryptocurrencies are also on its way to graduate to the mainstream, whereas other use cases with wider focus are set to hit the low point in term of disillusionment. The position of cryptocurrencies will probably be further revised given the decline in value of the flagship cryptocurrency Bitcoin by around 90 %, from its all-time high[1] in 2017 to today. Bitcoin value is highly volatile however, and it is difficult to predict how events such as COVID-19 will impact market capitalisation. It should also be noted that many emerging technologies have not managed to leave the 'trough of disillusionment'. For instance, speech recognition arrived at the Hype Cycle in 1995 and still has not managed to leave. Furthermore, we tend to be bad at predicting the future, and in the case of the Gartner Hype Cycle adoption, there could even be a strong case for arguing that technology adoption does not obey the Hype Cycle. Certain technologies die off and major technologies may fly under the radar.

Figure 3: Hype Cycle for Blockchain 2019

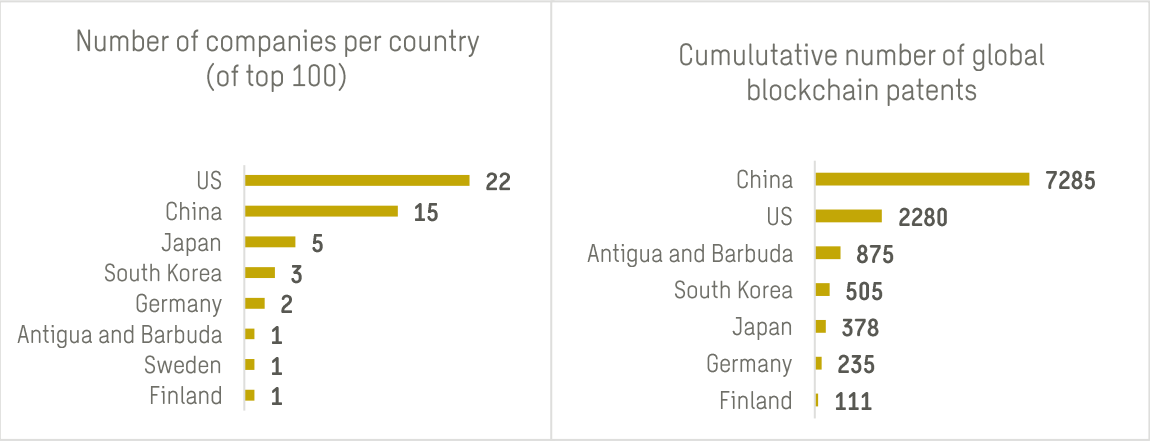


Source: Gartner 2019, see https://www.gartner.com/en/newsroom/press-releases/2019-09-12-gartner-2019-hype-cycle-for-blockchain-business-shows

[1] At the end of 2017, Bitcoin hit an all-time high of USD 19,783. At the time of writing, one Bitcoin is worth around 200 dollars.

When looking at patent filings US and China accounts for most patent filing companies of the top 100 companies. It should be remembered that most blockchain protocols are open source and these types of rankings do not necessarily spell out who the actual leader is but rather gives an indication of what countries provide a good platform for blockchain related patent filings. It also gives an indication of the relative weight and investment into the technology.

Figure 4: Blockchain-related patents of the top hundred companies per country and number of companies in (2019)



Source: IPRdaily[2], see http://www.ipdaily.cn/news_24501.html

Note: The numbers are based on the top 100 patent filing companies within blockchain

When looking at the breakdown of investments among European countries, the UK stands out capturing almost 70 % of all funding. UK´s role as a leader in Europe is also true when it comes to the number of blockchain start-ups.[3] Firms established in the Netherlands, came in second place with €352 million, also capturing a relatively large amount of the investment. But clear is that the UK has a key role in the among European countries both in terms of numbers of blockchain start-ups, and in the funds channelled into them.

Figure 5: Share in amounts received via all funding mechanisms by blockchain start-ups between 2009–2018 in Europe (total funding 2902 EUR million)

Source: Blockchain now and tomorrow, assessing multidimensional impacts of distributed ledger technologies; European Commission, Joint Research Centre; 2019; Venture Sources - Dow Jones

[3] Note: Total funding to blockchain start-ups between 2009–2018 was estimated to 2902 EUR million.

With the impact of the COVID-19 pandemic and the market chaos it has created, private investments into blockchain applications are feeling the pressure, even before the global health emergency was declared in late January. The impact is unprecedented on businesses across industries and niche markets, such as blockchain especially. Blockchain companies of all types and sizes are in the midst of re-evaluating plans and pivoting strategies. At the same time, the COVID-19 crisis is likely to significantly accelerate the shift to digital solutions which might mean new opportunities. Some commentators even see COVID-19 as the perfect use case for wider integration of blockchain.[4]

KEY CONCEPTS

The terminology in the field och blockchain is rapidly evolving and accepted definitions have not yet been formalized. Blockchain is simply put an architecture or data structure that employs cryptography and algorithms to record data in an immutable manner.

'Distributed ledgers' (DLs) are a specific implementation of the broader category of 'shared ledgers', which are simply defined as a shared record of data across different parties. A shared ledger can be a single ledger with layered permissions or a distributed ledger which consists of multiple ledgers maintained by a distributed network of nodes, as defined above. In this document, we are commonly using the term distributed ledgers (DLs), and specifically use the term blockchain only when referring to DLs that use a blockchain data structure. DLs are categorized as permissioned or permissionless, depending on whether network participants (nodes) need permission from any entity to make changes to the ledger. Distributed ledgers are categorized as public or private depending on whether the ledgers can be accessed by anyone or only by the participating nodes in the network.

TERMINOLOGY: What is blockchain and Distributed Ledger Technology (DLT)?
Technically, blockchain technology is only one explicit type of distributed ledger technology. Not all distributed ledgers employ blockchains and, conversely, blockchain technology could be used in other contexts. However, the terms 'blockchain technology' and 'distributed ledger technology' are generally used interchangeably. There are other categories of DLT, not relying on a 'chain of data blocks' as the primary technical datastructure. However, commonly, the term 'blockchain' is now usually used as a catch-all for all sorts of DLT. We apply the same principle for this document and use blockchain interchangeably with DLT. The European Commission also employs an understandable explanation[5] what Blockchain is:

"*Blockchain is the best-known distributed ledger technology. A ledger is a database which keeps a final and definitive record of transactions. Records, once stored, cannot be tampered without leaving behind a clear track. Blockchain enables a ledger to be held in a network across a series of nodes, which avoids one centralised location and the need for intermediaries' services. This is particularly helpful for providing trust, traceability and security in systems that exchange data or assets. There is a lot of potential for blockchain to be used in many different areas such as financial services, supply chains or healthcare.*"

BLOCKCHAIN EXPLAINED

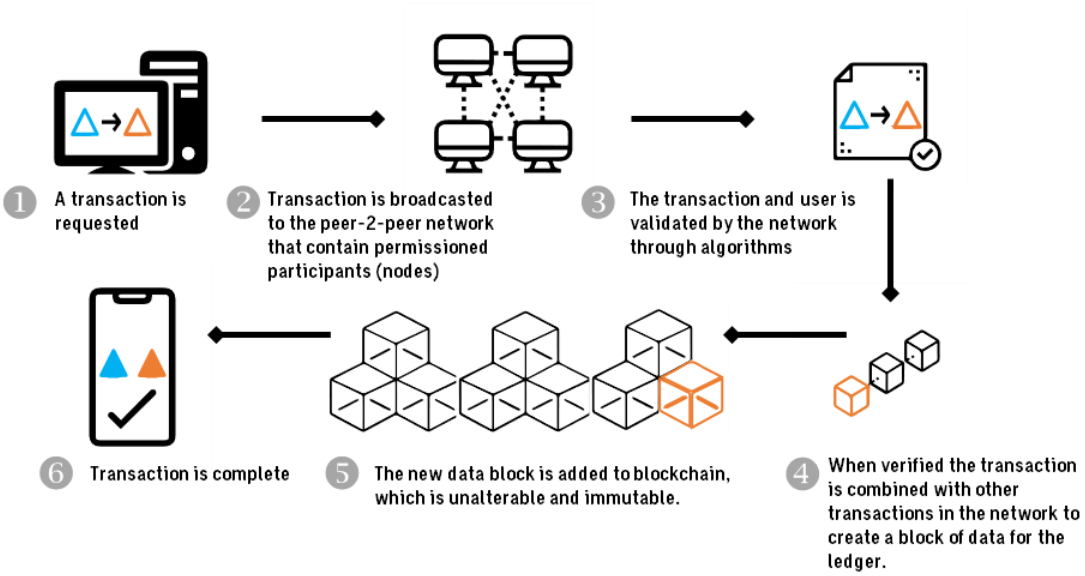
It is difficult to describe blockchain without becoming too technical. When Satoshi Nakomoto introduced the world to the technology in 2008 its main function was to serve as a distributed digital ledger for Bitcoin transactions.[6] Today blockchain is by some commentators referred to as one of the foremost technological innovations of the past decade. Others are less optimistic, but it is safe to say that it is a technology that has captured the public imagination.

At its core, blockchain enables large groups of individuals or entities, whether collaborators or competitors, to reach consensus on and immutably record this agreed-upon record of the truth permanently without a central authority.
As explained above, blockchain is simply a shared ("distributed" or "decentralised") database, what often referred to as a digital ledger. This ledger in turn uses cryptographic algorithms to verify the creation of digital assets and transactions taking place over a peer-to-peer network. Contrary to traditional databases, there is no need for a single party to keep records of all transactions that happen within a given system and no need for a single database. Data is instead cryptographically distributed across a diffuse network of nodes (e.g. servers or computers). By emphasising data redundancy with all network participants having a copy of the database, blockchain cuts out the need of a central ledger keeper and delegates this function of verifying and recording transactions to the users making the

[4] World Economic Forum, "Why COVID-19 makes a compelling case for the wider integration of blockchain", 8 May, 2020. URL: https://www.weforum.org/agenda/2020/05/why-covid-19-makes-a-compelling-case-for-wider-integration-of-blockchain/
[5] European Commission, DG CONNECT, 2019-06-11. How can Europe benefit from blockchain technologies? Url: https://ec.europa.eu/digital-single-market/en/news/how-can-europe-benefit-blockchain-technologies
[6] Nakamoto S. Bitcoin: A peer-to-peer electronic cash system. 2008

transactions. With the help of the of consensus protocols, users can then verify that all users are keeping the same records and that everyone has the same copy of the agreed-upon data (no one can alter the data). Blockchain technology has because of this been referred to as a "trust machine" since it provides an elegant solution to the problem of trust between networks and can enable large number of strangers to complete transactions with each other without risk of being cheated.

Figure 6: Simplified schematic of how a blockchain records transactions



Given the many and complex software architectures blockchain is currently deployed in we take a birds-eye view of the principles behind the technology rather than look at specific technical implementations.[7] The principles can in summary be said to be:

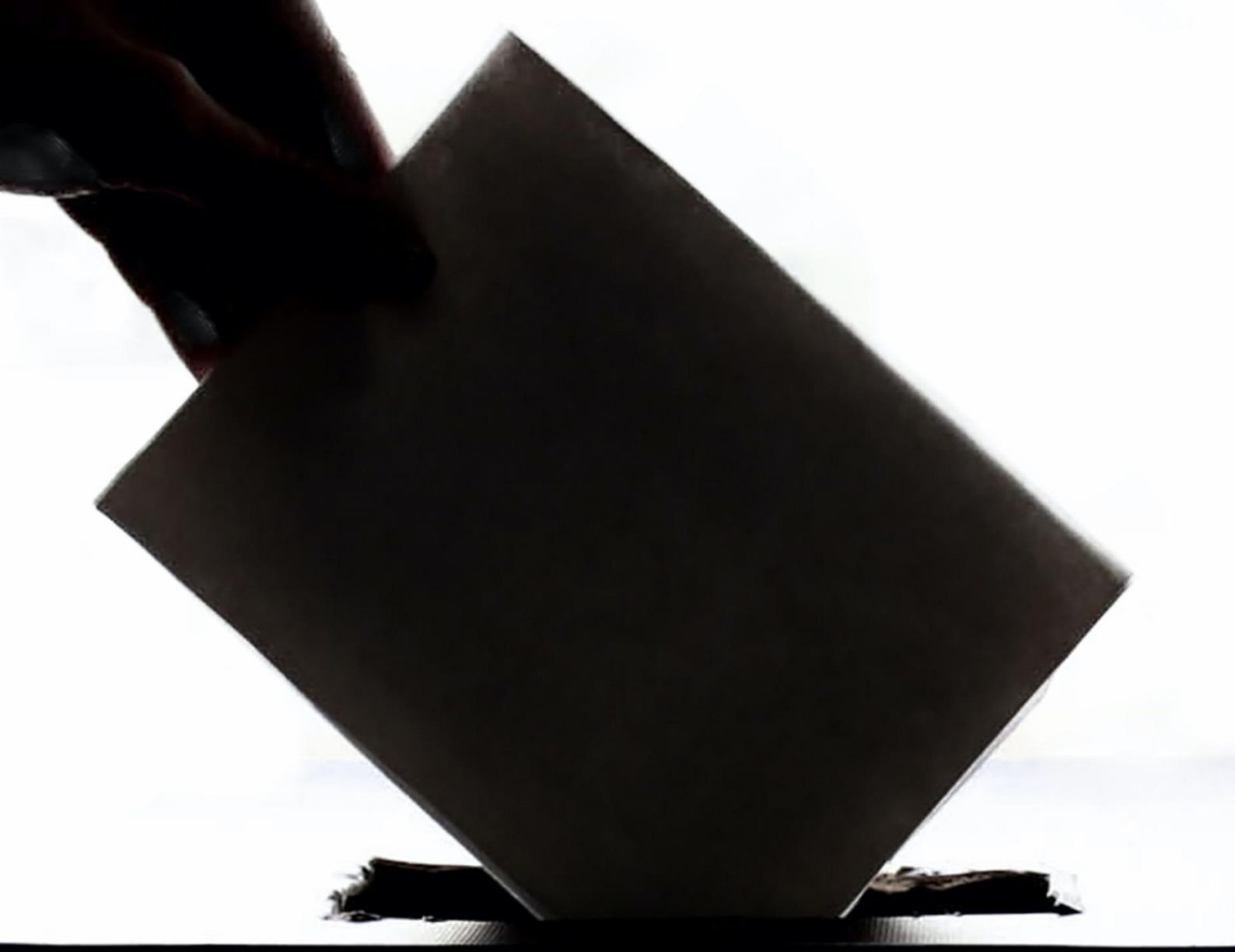
- **Widely distributed and redundant:** the blockchain platform is itself widely distributed, so that the information contained in the ledger exists in multiple locations, leading to high fault tolerance (failure of one or more components of the network does not cause failure of the entire system);
- **Degrees of transparency:** The ledgers are auditable by a predefined set of participants. For instance, in an open (public) blockchains everyone with internet access had the ability to verify the ledger. Records are therefor transparent and auditable. A ledger can contain plain text, be entirely encrypted, or broken into discrete elements, each encrypted with different keys, enabling a highly flexible model of information transparency;
- **Immutable and secure:** the blockchain ledger function under the principle of irreversibility of records; once a transaction is recorded, any change or tampering of that record cryptography is computationally impractical and cannot secretly be altered without letting the networking know. Any break would disturb the computed links (hash code) that connects each block with the preceding block breaking the "chain" and revealing the inconsistency. It is therefore easy to audit a blockchain and the links are visible to all permissioned users. Though security is a relative concept, blockchains are relatively secure because of this, it provides a tamper-proof ledger that is irreversible;
- **Decentralised consensus:** the mechanism used to commit a record to the ledger involves some form of consensus and can in some sense be thought of as "democratic" in the sense that a majority rules in determining what transactions are true and correct. There is no reliance on third parties or central authority to approve transactions and set rules. Untrusted participants reach consensus together.

Its most famous use case and the first asset on the blockchain was the cryptocurrency Bitcoin – a form of digital money not backed by any state. Beyond digital currencies, blockchains can be used to represent, track and trade a range of other types of assets. Today blockchain has evolved into a multipurpose technology, some advocates even

[7] Blockchain and Suitability for Government Applications; 2018

argue a general-purpose technology[8]. Advocates see blockchain as a game changing technology that will enable building a fairer, more secure and democratic digital economy that a has the potential to change both public and private sector radically.

[8] A general-purpose technology is a technology that has the potential to drastically alter societies through their impact. Classic examples include the steam engine and electricity.



2.

PUBLIC SECTOR USE CASES

2. PUBLIC SECTOR USE OF BLOCKCHAIN

There is much promise around blockchains application and almost an infinite number of potential use cases. Among the most frequently addressed use cases by governments include:

1. Title/asset registrations: including land or business registry
2. Educational certification and credentials:
3. Healthcare: including data for research or patient ownership of data and records. Given the sensitive nature of the data and problems with sharing data in multi-provider systems. Blockchain also offers a clear audit trail and ownership
4. Government funding: increasing accountability in aid spend or increased transparency in government expenditure.
5. Supply chain traceability and tracing: ensuring food safety or traceability of goods, as well as tracking volume of trade in goods.
6. Taxation and excise: combatting VAT fraud, streamline VAT systems and how tax is calculated and collected.
7. Democracy and dialogue: for instance, e-voting or the introduction of liquid democracy systems and improved
8. Identity: perhaps the widest use case for blockchain in government is that of digital identity.

This section presents some public sector examples of blockchain initiatives across Europe that focus on projects relating to democracy.

MAPPING OF EUROPEAN PUBLIC SECTOR BLOCKCHAIN PROJECTS

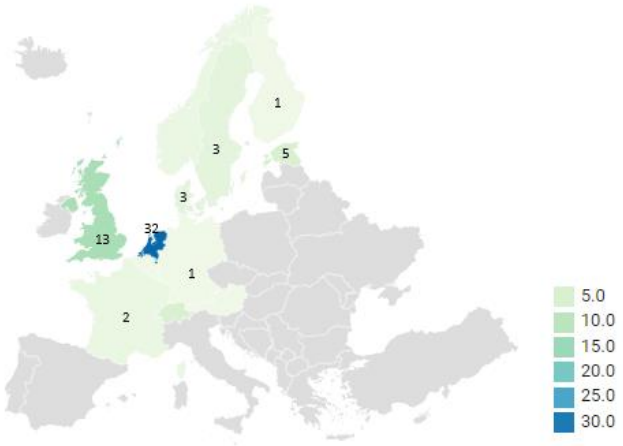
There are limited examples of scaled up public sector use of blockchain, especially as related to moving beyond proofs of concept. Estonia, with its e-Government approach, is the most advanced example of the exploitation of the technology in public sector. With a large ecosystem of around 3000 services, it includes e-voting as well as other services such as tax collection and identity management.

It is also true that available examples of public sector initiatives available tend to celebrate the successes and not the failures. A further complicating issue when identifying and mapping public sector blockchain projects is the lack of comprehensive databases. A consequence of blockchain technology only existing for little over a decade means that there is a lack of centralised data and statistics dedicated specifically to the domain of blockchain and especially public sector initiatives. For instance, one of the best curated databases available for public blockchain projects, the Blockchain in Government tracker[9], appears to have ceased data collection in 2017.

Similarly, the EU Blockchain Initiative mapping is based on data registered by contributors and then reviewed and added to the EU Blockchain Observatory and Forum map of blockchain initiatives.[10] This partially self-reported data is therefore neither systematic nor comprehensive. In Annex 1, we also include a list of the different Blockchain projects identified.

[9] The tracker is run by the Illinois Blockchain Project. See: https://illinoisblockchain.tech/
[10] See: https://www.eublockchainforum.eu/

Figure 7: European Blockchain initiatives (March 2018)



Source: OECD-OPSI Blockchain and its use in public sector, based on data from The Illinois Blockchain Initiative

There is a continuously growing number of blockchain initiatives that are being deployed by the public sector in different Member States. The Netherlands stands out in terms of the sheer number of deployed projects in the public sector, with over 32 recorded. However, finding accurate numbers on actual initiated projects is difficult.

Identifying examples that relate directly to democracy is even more difficult. Similar initiatives to that of Estonia have been implemented by other states - although at a narrower scope in terms of services. In Table 1 below, we provide some European examples of blockchain for democracy being used in a European context. Probably most famous example of e-voting using blockchain happened in the city of Zug (also referred to as Switzerland's Crypto Valley) which conducted a non-binding vote on several local issues.[11] With access provided to only 249 people, 72 ended up voting. Outside Europe there are also further pilots that have been trialled or planned:

3. The US state of West Virginia also successfully used blockchain-based e-voting in state primaries and the midterm election in 2018 to allow active-duty military personnel, their dependents, and other eligible overseas absentee voters to participate[12]
4. Although not specifically relating to political elections the Rock and Roll Hall of Fame used a blockchain voting system to register 1.8 million votes in 2017.
5. U.S. Congress is reportedly considering blockchain technology as a means for the Senate to facilitate remote voting amid the coronavirus pandemic.[13]
6. New South Wales, Australia saw one of the biggest deployments of i-voting (although not using blockchain). In 2015, 280,000 citizens case their vote however many security flaws were discovered.
7. Colombia, where the organisation Democracy.Earth offered expats a way to Colombia, where Democracy Earth offered Colombian expats a means to participate in a referendum on the peace treaty between FARC (Fuerzas Armadas Revolucionarias de Colombia) and the Colombian government[14]
8. South Korea is also testing a blockchain based solutions for voting.[15] Recently, the capital city Seoul also added blockchain functionality to their citizen engagement platform ´Democracy Seoul'. This experiment in citizen engagement allows people to propose, debate and vote on topics (see Liquid Democracy). To date, almost 6,000 proposals have been received since inception in 2017 and 59 have become city policy.[16]

[11] Swiss e-voting system hack shows value of blockchain-based election technology, Modern Consensus, March 14, 2019. URL: https://modernconsensus.com/regulation/europe/zug-switzerland-e-voting-flaw/
[12] Blockchain elections: How Bitcoin tech could secure your vote - and save democracy, ZDNET, February 4, 2020. URL: https://www.zdnet.com/article/blockchain-elections-how-bitcoin-technology-could-secure-your-vote-and-save-democracy/
[13] "US Congress Considers Blockchain-Based Voting Amid COVID-19", Haig, Samuel. Cointelegraph, 3 May, 2020. URL: https://cointelegraph.com/news/us-congress-considers-blockchain-based-voting-amid-covid-19
[14] Embracing Innovation in Government: Global Trends, OECD, Feb 2017, URL: https://www.oecd.org/gov/innovativegovernment/embracing-innovation-in-government-colombia.pdf
[15] "South Korean Government to Test Blockchain Use for E-Voting System, Max Yakubowski, Coin Telegraph, November 28, 2018. URL: https://cointelegraph.com/news/south-korean-government-to-test-blockchain-use-for-e-voting-system.
[16] Seoul uses blockchain in referendum system to reduce double voting, Ledger Insight, February, 2020. URL: https://www.ledgerinsights.com/blockchain-voting-referendum-democracy-seoul/

9. India, the world's largest democracy, is also considering the introduction of blockchain based application to combat the shrinking of voter turnout with an aim for roll-out 2021.[17]
10. Thailand's National Electronics and Computer Technology Centre (NECTEC) has already completed the development of a system for blockchain-based voting and are looking into trialling it.[18]

Some high-profile examples have also stalled. Although not specifically relating to Europe, the Swiss foundation Agora was widely reported to have powered the first blockchain election. On further inspection, this was renounced by the National Electoral Commission of Sierra Leone and Agora later acknowledged they only tested to record a few votes on the blockchain.[19] The government of Moscow also introduced a digital voting system but was found to have critical security flaws that allowed it to "be broken within 20 minutes".[20] Criticisms to the system was also put forward by one of the losing candidates, arguing that the offline results did not tally with those submitted electronically. Severe privacy concerns were also raised when it was discovered that it was possible to decode the votes, which made it possible to identify how people had voted.[21]

Table 1: Examples of European government blockchain projects related to voting and civic participation[22]

Country/entity	Project / initiative	Application level / domain
Denmark	The Denmark Liberal Alliance has introduced a blockchain based system called "Follow My Vote" that acts as a digital ballot system.	Organisation / Local
Estonia	In 2005, Estonia became the first country in the world to hold nationwide elections using i-Voting, and in 2007, it made headlines as the first country to use i-Voting in parliamentary elections.	National
Finland	Decisions Helsinki is a tool to follow notifications of municipal policy decisions. By using the municipal open API on town hall agendas, the service allows citizens to sign up to be notified when decisions are made about issues that are of interest or concern to them.	
Norway	The voting system in Norways was developed to mimic that of Estonia's and tests for local and national elections was conducted in 2011 and 2013. The system was however abandoned in 2014 due to lack of voter confidence and fears of compromising voter secrecy.	National
Germany	North Rhine-Westphalia has enabled citizens to use blockchain technology to verify data published.	Municipal
Germany	The Pirate Party of Germany has also experimented with using blockchain driven liquid democracy applications.	Local

[17] Working on a tech solution for 'lost votes', says CEC. The Times of India, 12 February, 2020. URL: https://timesofindia.indiatimes.com/india/working-on-tech-solution-for-lost-votes-says-cec/articleshow/74109019.cms
[18] Nectec develops blockchain for elections, Bangkok Post, 3 January, 2019. URL; https://www.bangkokpost.com/business/1604574
[19] Sierra Leone's electoral commission is pushing back on reports that blockchain powered its election, Quartz, 21 March 2018. URL: https://qz.com/africa/1234268/sierra-leone-blockchain-election-election-commission-denies-use-of-blockchain/
[20] Moscow's blockchain voting system cracked a month before election, ZDNET, 20 August, 2019. URL: https://www.zdnet.com/article/moscows-blockchain-voting-system-cracked-a-month-before-election/
[21] Moscow Said to Hire Kaspersky to Build Voting Blockchain With Bitfury Software, Coindesk, 7 June, 2020. URL: https://www.coindesk.com/moscow-said-to-hire-kaspersky-to-build-voting-blockchain-with-bitfury-software
[22] A more comple list of blockhain initiatives is available in Annex 1

Italy	Forza Italia (FI) has expressed some interest for blockchain with with the coordinator of the FI clubs set in the United Kingdom, endorsed the project Multiversum as a tool to improve the voting procedure of Italians living abroad. However, after collecting $21 million during its ICO, in 2018, this project for a new generation blockchain enabled voting encountered difficulties to move on to an operational stage.[23]	
Spain	Podemos, a political party in Span has, similar to the Denmark Liberal Alliance, introduced a ballot voting system based on blockchain.	Organisation / Local
Switzerland	The city of Zug[24] tested a government-issued self-sovereign identity on the Ethereum blockchain. Implementation includes Digital identity for proof of residency, eVoting, payments for bike rental and parking. Live since November 2017. In April 2018 around 300 of the 30,000 residents had signed up.[25]	

Source: Sweco´s own elaboration based on Illinois Blockchain Project and EU Blockchain Observatory and Forum map

WHEN TO USE BLOCKCHAIN IN THE PUBLIC SECTOR

The application of blockchain tends to gravitate around three different outlooks:

1. **Snake oil:** it is another new over-hyped technology, one among many, that does not offer anything new to existing legacy systems and processes
2. **Technological breakthrough:** it represents significant or noticeable improvements process and task execution, with faster transaction speed, transparency, immutable data etc.
3. **Game changer:** blockchain fundamentally changes the way business is conducted around any transaction, creating decentralized, participant-based ecosystems and disintermediating the world.

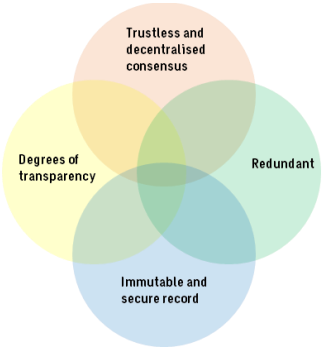
The view you take will influence many of the decisions around supporting and investing in blockchain solutions. Europe has seen significant levels of interest from governments and private business in blockchain. Universities and researchers, often supported by the EU, are looking into the use of blockchain and related areas. As such, there is support on both a policy level and as we saw on the public sector deployment side. Among the advocates that see blockchain as a game changer, there is hope that it will involve radical transformation and strengthening of governance and democratic processes.

[23] "Crypto-Italy: Institutions, Politics, Business and Society", Pozzi, S. 26 May 2019. URL: https://cointelegraph.com/news/crypto-italy-institutions-politics-business-and-society
[24] For an indepth look at the project and case study see: Self Sovereign Identity for Government Services in Zug, Switzerland. URL: https://blockchan.ge/blockchange-government-services.pdf

Blockchain is best suited for use cases requiring at least three of the following principles (see figure): data redundancy; information transparency; data immutability; and a consensus mechanism. If only one or two are required then blockchain may work, but there are likely simpler and / or cheaper ways to solve the problem.

This is especially important in the public sector. Blockchain is not the panacea to all issues and many times traditional legacy systems offer better and cheaper solutions. If only selective transparency is needed or immutable record is needed other solutions should be investigated first. At the same time the public sector also has a greater responsibility to provide services that are equitable, transparent and accessible.

Figure 8. Core attributes of blockchain



BLOCKCHAIN AND THE CITZEN - TRUST-BY-COMPUTATION

> "The Brexit vote to leave the European Union ...[is] the first wave of acute symptoms emerging from one of the biggest trust shifts in history: from the monolithic to the individualized. Trust and influence now lie more with 'the people'– families, friends, classmates, colleagues, even strangers–than with top-down elites, experts and authorities. It's an age where individuals matter more than institutions and where customers are social influencers that define brands"
>
> -Who Can You Trust?: How Technology Brought Us Together and Why It Might Drive Us Apart by Rachel Botsman

Since the early 2000s, it has been anticipated that e-voting will lead to faster, simpler, cheaper elections as well as higher participation rates. Two decades later, that promise of a 'deeper democracy' through internet communication technology not been realized. Elections are still largely conducted offline. Only a few European countries such as Estonia, Netherlands and Switzerland have implemented e-voting systems for parliamentary elections. In most cases however, these have been discontinued, Switzerland banned the practice for five years after concerns over security emerged and, in the Netherlands, it was discontinued in 2007. Similarly, the German court ruled e-voting unconstitutional[26].

However, with the help of blockchain, there are hopes of a more secure and better way of conducting elections, be it parliamentary or smaller scale, counteracting the "de-institutionalisation" and delegitimization of government, and the lack of trust in central authorities such as the EU (e.g. Brexit). With declining voter participation in Europe and overall decline in citizen involvement in political parties, blockchain could offset this trend by reshaping the democratic process by managing social interactions on a large scale and dismiss traditional authorities.[27]

By shifting from a central institution and the State to a blockchain platform based on decentralised trust, techno-libertarians envision citizens that can self-create their own governance models. from centralised and hierarchical authority structures to an architecture based on decentralised trust. Some enthusiasts even go so far to envision

Decentralized Autonomous Organizations (DAOs) are established and governed according to rules that are coded in computer software, sometimes called a "smart contract," which may be implemented by blockchain technology. Instead of managers there is a software protocol governing work. Any information in the organisation is not filtered through a hierarchy but transparently recorded on the chain. Any strategic decision making is done through a democratic vote rather than by an CEO.

Source: Hsieh, Y., Vergne, J., Anderson, P. et al. Bitcoin and the rise of decentralized autonomous organizations. J Org Design 7, 14 (2018). https://doi.org/10.1186/s41469-018-0038-1

[26] German court rules e-voting unconstitutional, DW, 3 March 2009. URL: https://www.dw.com/en/german-court-rules-e-voting-unconstitutional/a-4069101

[27] The Decline of Political Participation: An Empirical Overview of Voter Turnout and Party Membership. Siaroff A. (2009), In: De-Bardeleben J., Pammett J.H. (eds) Activating the Citizen.

blockchain technology could be the basis of decentralised autonomous organisations DAOs or even societies (see box below).

The EU position is less enthusiastic but recognises the potential of blockchain to enhance democracy by enabling certain groups (for examples, expatriates or disabled people) to vote, but also insist on the need to prevent fraud and ensure voter secrecy.[28]

The idea of liquid democracy (see box below) is proposed by some advocates as an elegant solution to the 'democracy deficit'. By making the electoral process cheap and quick, it could in theory normalize the process in the eyes of the voters, and by so doing remove a certain power barrier between the voter and the elected official, as well as put a certain amount of accountability on the officials. It also opens the door for a more direct form of democracy, allowing voters to express their will on individual bills and propositions. However, few actual examples involving public sector actors are currently available. The Silicon Valley project, Democracy.earth, is currently experimenting with blockchain based liquid democracy that empowers direct voting on issues, delegation of voting power on topics to peers without central authority.[29] Similarly, the Berlin-based non-profit Liquid Democracy e.V. is developing online collaboration platforms for cities, political parties.[30] Both of these groups are trying to bring democracy into the digital age and give control to citizens on which topics they engage on.

Liquid democracy also called 'delegative democracy' is not a well-defined concept but represents a rather broad set of ideas. At its core it is based on a combination of the advantages of direct democracy and representative democracy. It was designed to make every user a potential politician, by combining direct and representative systems of decision-making. A member (citizen) can assign either vote directly or delegate a proxy vote to any other member, thereby assigning a personal delegate. Rather than always having to vote on all issues as in direct democracy or on a candidate or party in an representative democracy, a participant can give their vote to another member for all issues, for a particular policy area, or for a particular decision for a limited length of time. With citizens being able to make decisions through the collective intelligence advocates believe that this will result in everyone's voice being heard, more transparency, increased participation and when trust is broken (e.g. corruption) citizens can deviate vote to others. Several European Pirate Parties have introduced liquid democracy approach into their governance models.
Source: Ramos, Jose. (2015). Liquid Democracy and the Futures of Governance. 10.1007/978-3-319-22994-2_11.

THE CHALLENGE OF IMPLEMENTATION FOR PUBLIC SECTOR

We have a relatively poor track record when it comes to predicting what a new technology might mean over the long run. In addition, we have an even poorer record knowing in advance what is truly disruptive. Blockchain fits the bill of a disruptor, as described in previous chapters, but still lacks maturity. What exactly will be the use of blockchain in the public sector is therefore very hard to predict.

Despite the enthusiasm of its advocates, the scientific community generally agrees in stating that blockchain and its many clones are based on a still relatively immature and at times vulnerable technology. A full analysis of blockchain technical weaknesses falls beyond the scope of this report, but we will offer a brief summary of the most relevant risks and for the public sector on this topic. Some of the challenges listed for the public sector are:

- **Any attack can scale well:** An exposed flaw could compromise the security, civil rights and privacy of millions of citizens in for instance a public election. In the case of physical voting, it is not perfect, but changing votes often requires considerable resources and time to scale.
- **Legitimacy:** In the case of voting blockchain versus paper ballots, citizens puts the trust in the algorithm rather than the physical counting. Citizens would need to trust software and hardware without necessarily understanding how it works. A sophisticated attack and disinformation campaign could easily cast doubt about the legitimacy of an election.
- **Future proofing:** the rapid development of the technology might expose security risks and breaches of privacy. For instance, quantum computers could disrupt the cryptography underpinning blockchain.

[28] "Digital technology in elections", European Parliament Research Service, September 2018. URL: https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/625178/EPRS_BRI(2018)625178_EN.pdf
[29] See https://democracy.earth/
[30] See https://liqd.net/en/about/

Furthermore, changes in underlying technology (e.g., from traditional databases) requires a significant investment in time and funds.

- **Poor implementation:** Software developers can make mistakes when coding new blockchain software.[31] For instance, the highly lauded Estonian e-voting system has been criticised for procedural and operational flaws. Similarly, 2015, an activist from the Estonian Pirate Party, took credit for casting an invalid ballot.[32]
- **Attacks:** attacks can target devices and system software using blockchain. Similarly, depending on how the blockchain is deployed, there are other vulnerabilities that might be exposed.
- **Legal uncertainty:** in the short-term there is a need for legal and regulatory clarification as well as standards. Implementing blockchain solutions are still prone to many open legal compliance issues.

Any public sector initiative involving the digitalisation of democratic processes require a high degree of reliability, accessibility and predictability. It also needs to be tolerant of interruption or failure. A coding flaw in the management or in the implementation of such a network would compromise the security, erode trust and potentially harm the rights of many millions of citizens. For instance, security is still very much an open question. Several high-profile cases of cryptocurrencies being hacked and having vulnerabilities exploited has occurred. For public sector institutions to be democratically legitimate, they must ensure the secure storage of often extremely sensitive and personal data in relation to voting, among many other activities.

Blockchain-enabled voting is not only a digitisation of the traditional voting process – it also comes with a new set of political values. When traditional authorities manage elections there is an assumption of trust on behalf of the citizen – the process is top-down, centralised and black-boxed. In blockchain-driven elections, this would be the opposite – transparent, bottom-up and decentralised. The potential erosion of the authority of the state, shifting power and trust away from central actors towards the primacy of people and community of consensus, could therefore challenge existing power structures. As such, blockchain-enabled voting might be better suited for smaller scale implementation, such as organisations or municipalities, with issue-specific voting rather than for general political elections on a national scale.

In table 2 below, we have analysed the different strengths and weakness that can be considered when analysing potential application of blockchain to voting.

[31] Mike Orcutt, "How Secure is Blockchain Really?" MIT Technology Review, April 25, 2018, https://www.technologyreview.com/s/610836/how-secure-is-blockchain-really/.
[32] L og Analysis of Estonian Internet Voting 2013–2015, Sven Heiberg1 , Arnis Parsovs and Jan Willemson, 2015.

Table 2: SWOT of blockchain based voting versus traditional paper voting[33]

	Blockchain based e-voting	Traditional "physical" elections
Strength	• Immutable records. Deleting records is difficult and auditability is possible • Transparency with privacy (in theory) • Cost-efficient in the long term • Enables custom elections with different durations, conditions, and target groups. • Instant results	• People trust the paper-based voting and counting, as long as the process is transparent. • Does not rely on internet and computers, good for regions with low internet existence/usage.
Weakness	• Integrity will depend on the implementation. Technology is new, security and scalability are issues. Still debatable to which extent anonymity, security and accessibility. • Procurement for public authorities is difficult due to information asymmetry and a rapidly evolving market landscape • Technology is not yet mature • Initial deployment costs are high • Monitoring of elections difficult; full technical analysis is likely to exceed capacity of electoral monitors • Trust and legitimacy in the process and the system is a barrier to mainstream adoption	• Costs are high in the long term • In-person attendance may be hard and annoying. • Physical security against tampering is difficult and expensive • Voting difficult for small and far-away settlements • Voting stations can become targets for intimidation or terrorism • Traditional voting also shares many of the same issues as with blockchain around anonymity, coercion and accessibility
Opportunities	• New approach to improve voting transparency • Could offer a secure way for remote participation and voting • Secure storage and records • Once accepted, easier for marginalized groups such as visually impaired / disabled people to participate • Might bring more empowerment of citizens, democracy to government units, local administrations.	• Less prone to attacks on legitimacy (established method) • Easier and cheaper for smaller and non-distributed groups.
Threats	• If system is compromised, the attackers can scale impact • Unknown technological risks in the future (e.g. quantum computers could disrupt the cryptography underpinning blockchain)	• Human error may cause mistakes during tallying votes • Physical elections also prone to tampering, voter intimidation and fraud • Physical attacks may block or distort the voting process. • Re-holding elections is costly, in case of appeals • Obstacles to holding elections may result in having fewer elections

[33] Table adapted from A Survey on Feasibility and Suitability of Blockchain Techniques for the E-Voting Systems, Çabuk, Adıgüzel and Karaarslan. International Journal of Advanced Research in Computer and Communication Engineering, 2018.

3.

CONCLUSIONS AND RECOMMENDATIONS

3. CONCLUSIONS AND RECOMMENDATIONS

Amara's law states that we tend to overestimate the impact of a technology in the short run and underestimate it in the long run. We have tried to avoid the pitfalls of Amara´s law – neither overestimating blockchains transformational impact – nor underestimating the potential. We believe that blockchain is worth a deep exploration and experimentation in the public sector. This will take purposeful collaboration and a willingness to engage with new ways of delivering public services. However, we still see that in many cases, blockchain is not as disruptive in the public sector as it is often portrayed. New blockchain systems do not provide the disintermediation of public services or replace existing systems.

The application of blockchain technology to bring the citizen closer to political decision-making offers interesting but challenging prospects. As a tool for social innovation from the grassroots, however, blockchain is more an emerging rather than a developed technology. More time is needed to solve the underlying issues before blockchain´s full potential can be harnessed.

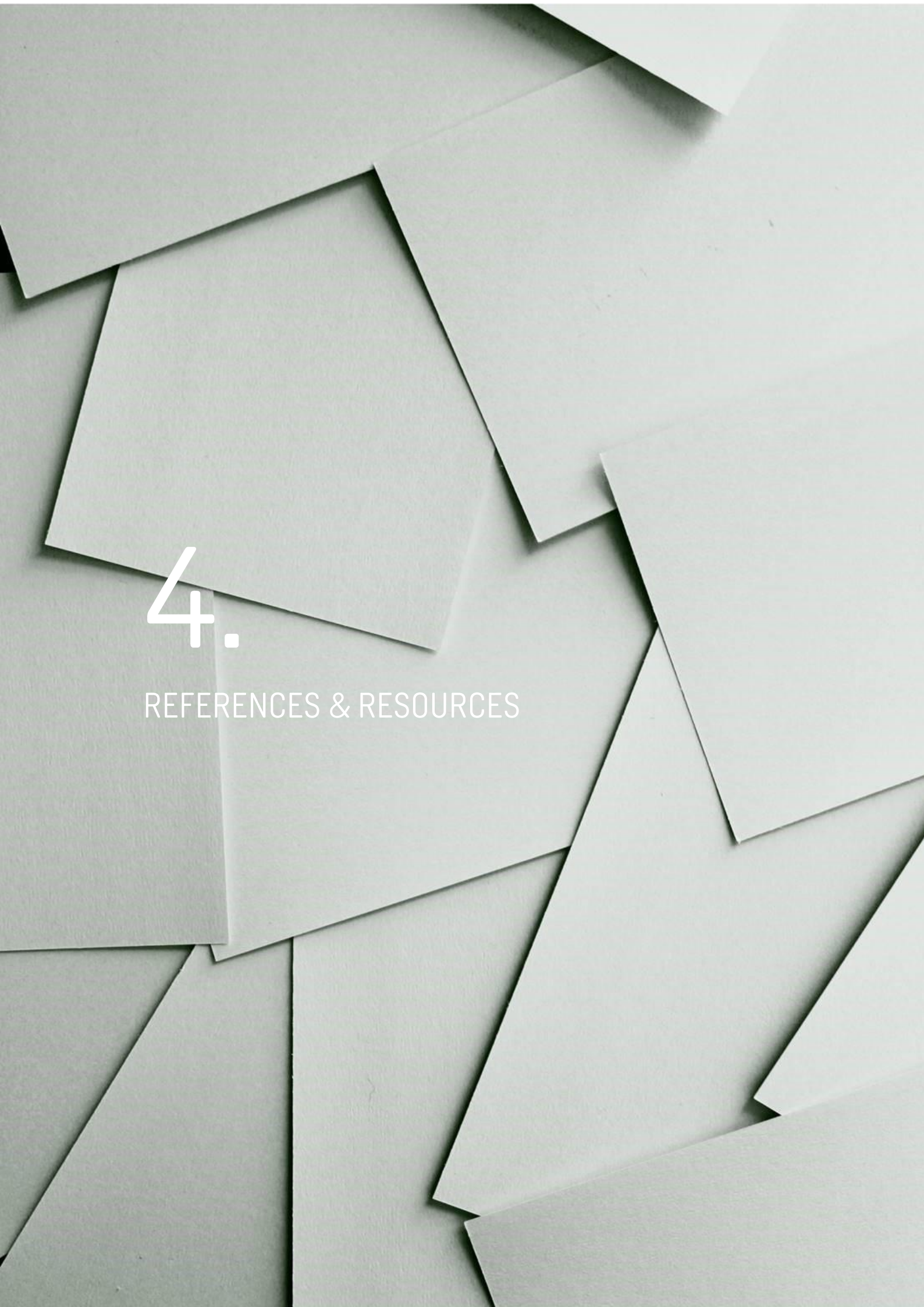
Blockchain in the public sector is at a defining stage in a rapidly evolving landscape. There are few easy answers to come by and little established expertise on what works in the public sector. As we have seen in the preceding chapters, trust is a key factor. We do not considerate blockchain as 'snake oil' but we would like to caution against an overly optimistic view when looking to implement blockchain in public sector. The case made by supporters that blockchain could act as a transparent scorekeeper in elections that cannot be hacked, is not entirely clear.

All important technologies do however carry risks, as does blockchain, and this risk will be borne by institutions that deploy them. It requires a deliberate effort with regard to our idea of what democracy is that involves not only technologists but social sciences and citizens to best assess risks, benefits and outcomes of this new technology. Maintaining the stability of our democratic systems is as important as the state maintaining a monopoly on the use of force. Therefore, starting small, on city or local level, is recommended when experimenting with new ways of governance processes. This will provide space to grow the know-how in public sector and allow for the basic blockchain infrastructure to reach critical mass. It will also avoid technological or vendor lock-in effects that could make large-scale solutions risky.

Blockchain is often viewed as an end in itself, not as a tool. Although it has the elicited considerable excitement, we are only seeing the start of the different use cases that are attempting to transform and improve democratic processes. Risks need to be carefully weighed against benefits, avoiding overly optimistic expectations. With time, the operating environment for blockchain will become more stable with reduced uncertainty which will encourage adoption in public sector. There exist many use cases already where public services through blockchains is possible and even desirable, where blockchain is well-suited to delivering tangible increases in public sectors functionality.

Public sector also has an important role to play both by supporting deployment when it makes sense, and supporting the innovation in blockchain systems. Policymakers should ensure a level playing field for blockchain applications that is neutral, and strive to reduce costs and avoid fragmentation of regulations.

Finally, if the enthusiasts are to be believed and blockchain is in fact a general-purpose technology, it will take a long time to diffuse through society. Eventually it will however lead to gains across multiple sectors. Only time will tell what the next "killer app" for the blockchain will be.



4.

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RESOURCES

Useful introductions to blockchain

- Primer on Blockchain including how it works, its history, smart contracts, and applications of the technology (Blockchain Technology Primer, IAB Tech Lab, 2018)
- E-public, e-participation and e-voting in Europe – prospects and challenges (European Parliament Science and Technology Options Assessment, 2011) includes a detailed discussion on the issues surrounding internet voting.
- A deep analysis on blockchains impact on democratic systems. Blockchain Technology and Decentralized Governance: Is the State Still Necessary?
- Blockchain applications in government, provides a systematic literature review of current state of affairs in research and the challenges faced in the adoption of blockchain technologies in the domain of e-Government.
- Joint Research Centre, "Blockchain now and tomorrow, assessing multidimensional impacts of distributed ledger technologies" gives a good understanding of the blockchain landscape as well as providing a good primer to the subject.

Blockchain organisations

- The European Union Blockchain Observatory and Forum aims to accelerate blockchain innovation and the development of the blockchain ecosystem within the EU, and so help cement Europe's position as a global leader in this transformative new technology. They also offer a wide selection of thematic reports relating to blockchain and public sector.
- European Blockchain Association is an independent platform for blockchain-related communities and organizations to discuss, develop and elaborate on shared work.
- INATBA (International Association for Trusted Blockchain Applications) multi-stakeholder organisation based in Brussels. It brings together suppliers and users of Distributed Ledger Technologies with representatives of governmental organisations and standard setting bodies from all over the world. They share the common vision of promoting transparent governance, interoperability, legal certainty and trust in services enabled by blockchain and DLT.
- Dutch Blockchain Coalition partnership between government, knowledge institutions and industry. DBC's mission is to advance reliable, robust and socially accepted blockchain applications, create the best possible conditions to allow blockchain applications to arise, and utilise blockchain as a source of trust, welfare, prosperity and security for citizens, companies, institutions and government bodies.

ANNEX 1: PUBLIC SECTOR BLOCKCHAIN PROJECTS

Country/entity	Project/initiative	Application level/domain
Identity		
European Blockchain Partnership	As part of European Blockchain Service Infrastructure initiative there is exploration on an EU-wide identity management structure and how to make this compliant with eIDAS (EU-regulation that governs how Member States accept legally binding electronic signatures and identities). European Self Sovereign Identity Framework (eSSIF) is an initiative which aims to allow users to create and control their own identity across borders.	EU-level
Finland	The Finnish government has worked with a local startup to introduce a blockchain-based identity system for refugees in Finnish refugee centres that is linked to a debit card the refugees can use to purchase food and other necessities	Local
Switzerland	The city of Zug[34] tested a government-issued self-sovereign identity on the Ethereum blockchain. Implementation includes Digital identity for proof of residency, eVoting, payments for bike rental and parking. Live since November 2017. In April 2018 around 300 of the 30,000 residents had signed up.	National
Certification / accreditation		
Malta	Blockcerts is an Initiative that applies an open standard for creating, issuing	National / academic certificates

[34] For an indepth look at the project and case study see: Self Sovereign Identity for Government Services in Zug, Switzerland. URL: https://blockchan.ge/blockchange-government-services.pdf

	and verifying blockchain based academic certificates.	
Germany	North Rhine-Westphalia has enabled citizens to use blockchain technology to verify data published	Local
Asset / title registration		
Denmark	Vehicle wallet. A public private partnership where Blockchain-based innovation is used to co-create a proof of concept on registered digital asset management for handling a vehicle's life cycle process. All data concerning the car is saved in one distributed ledger and creates one agreed and shared record of the vehicle history as it is transferred across the supply chain.	National
Norway	A platform where transparent shareholding in small and medium sized enterprises fosters innovation.	Local
Swedish land registry	Real-estate transfers and other multi party transactions. Completed a proof of concept.	National / land registry
United Kingdom	HM Land Registry is deploying a proof of concept project called "Our Digital Street" which aims to enable digital transfers of land titles.[35]	PoC / National
Blockchain infrastructure		
United Kingdom	Blockchain as a service for each government department as well as local authorities which means they are free build and deploy secure, enterprise-grade DLT services if they so wish.	Available since August 2016.
United Kingdom	UKs Food Standards Agency completed a pilot to track the distribution of meat	This trial finished in July 2018 marked the first

[35] Could blockchain be the future of the property market? HM Land Registry, 24 May 2019. URL: https://hmlandregistry.blog.gov.uk/2019/05/24/could-blockchain-be-the-future-of-the-property-market/

	in a cattle slaughterhouse using blockchain.	time that blockchain technology has been used as a regulatory tool to ensure compliance in the food industry.
Healthcare		
Estonia	In 2016, the Estonian E-Health Foundation launched a development project aimed at safeguarding patient health records using blockchain technology in archiving related activity logs.[36] Now	National
Blockchain governance		
Luxemburg	Infrachain governance framework is a trusted blockchain infrastructure, developed jointly by the public and private sectors, aims to facilitate the deployment of solutions based on blockchain technology, both for start-ups and established actors, within a regulated framework.	National
Transaction services / government services		
The Netherlands	Dutch pension funds APG and PGGM said completed an initial phase of a joint experiment involving a blockchain application to develop an advanced pension administration system in 2017.	National
The Netherlands	Stadjerspas smart vouchers. The project is a benefit management for low-income residents in the municipality of Groningen	Local
United Kingdom	The UK government's Department of Work and Pensions (DWP) tested an experiment in which a blockchain system is used to distribute welfare payments.	Pilot / Local

[36] E-estonia. 2020. URL: https://e-estonia.com/solutions/healthcare/e-health-record/

	Announced in July 2016, DWP ran a trial proof of concept on a small scale and the findings concluded that it was not viable due to limited take up potential and the expenses it would incur	
Utilities		
United Kingdom	Blockchain supported Grid. Blockchain-based notarisation of the use of public utilities and public services by multiple parties, to facilitate usage-based invoicing and reconciliation	National
Legal compliance / transparency		
Colombia	In partnership with the Inter-American Development Bank (IDB) and the Office of the Inspector General of Colombia (Procuraduría General de Colombia), the Forum has led a multistakeholder team to investigate, design and trial the use of blockchain technology for corruption-prone government processes, anchored in the use case of public procurement.	Pilot / local