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The uncertain promise of blockchain for government

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Foreword

Blockchain technology remains a hot topic for digital transformation and innovation, as blockchain and its underlying distributed ledger technology have the potential to fundamentally transform a wide range of industries and markets. In addition to the private sector, where blockchain has demonstrated disruptive potential through a series of proven use cases in areas such as fintech and asset management, interest for public sector applications of blockchain technology remain high. Governments continue to show strong demand for investments in blockchain efforts for identity, records and supply chain management, financial services, land titles, and other applications. Likewise, the OECD is closely monitoring developments involving blockchain technologies through its Global Blockchain Policy Centre (https://oe.cd/dlt), Global Blockchain Policy Forum, and reports and research that span the wide array of policy domains covered by the OECD, including public sector blockchain, as covered by the OECD's Observatory of Public Sector Innovation (OPSI; https://oecd-opsi.org) and Digital Government and Data Unit (https://oe.cd/digitalgov).

It has been over two years since OPSI published the paper *Blockchains Unchained: Blockchain Technology and its Use in the Public Sector* (https://oe.cd/blockchain), and over a year since the Digital Government team and its Working Party of Senior Digital Government Officials (E-Leaders) published the paper *State of the Art in the Use of Emerging Technologies in the Public Sector* (https://oe.cd/et-gov). These papers sought to help public servants look past the hype surrounding blockchain and understand what blockchain is (and isn't), the implications it could have on government services, and the opportunities and challenges governments may face as a result. They also surfaced hundreds of blockchain initiatives underway in dozens of countries around the world.

While these papers identified interesting pilots and provided valuable early lessons, since then we have not seen breakthrough innovations in government, or many projects that have moved beyond proofs of concept or small pilots. At the same time, there have been a number of public sector blockchain controversies and a growing scepticism and cynicism about the use of blockchain in government. In working with governments, officials have also cited struggling with challenges related to coordination and demonstrating legitimacy of the technology. Simply put, blockchain projects have had minimal impact on the public sector so far.

This paper seeks to understand why this is the case by reviewing the latest research in the area, as well as identifying and analysing public sector experiences on successful government blockchain projects that have been implemented and have gained users, as well as those projects that did not successfully reach the implementation phase. It provides early and observational evidence on beliefs, characteristics, and practices related to blockchain projects and the organisations that seek to implement them, with a focus on factors that lead to success or non-success.

Although blockchain has yet to impact or disrupt the public sector in the ways that early hype had predicted, government decision makers will need to understand and continue to monitor this rapidly emerging technology closely. Blockchain technology, when specifically and appropriately applied, may still hold significant potential for the transformation and innovation of public policies and services. This paper, developed under the purview of the OECD Public Governance Directorate (GOV) and its OPSI and Digital Government and Data Unit, can help to maximise this potential, while minimising unwarranted hype, unrealistic expectations, and misinformed investments. This paper is published as part of the OECD Working Papers on Public Governance and the OECD Blockchain Policy Series.

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The paper was produced under the purview of the Observatory of Public Sector Innovation (OPSI) and the Digital Government and Data Unit. It was prepared in collaboration with the Network of Observatory National Contacts Points, the Working Party of Senior Digital Government Officials (E-Leaders), and the OECD Global Blockchain Policy Centre.

The paper was principally authored by Juho Lindman, Associate Professor of Information Systems Science at the University of Gothenburg, with significant portions of Chapter 4 on Organisational Success authored by Mariane Piccinin Barbieri of the Digital Government and Data Unit (Digital Gov), which builds on the work produced by the Digital Government Policy Framework and Digital Government Index, led by Felipe González-Zapata of Digital Gov. The work was carried out under the leadership of Jamie Berryhill of OPSI and Benjamin Welby of Digital Gov, with guidance provided by Marco Daglio, Head of OPSI, and Barbara Ubaldi, Acting Head of Division and Head of Digital Gov, in coordination with Caroline Malcolm, Head of the Global Blockchain Policy Centre.

The OECD team also wishes to acknowledge the contributions of numerous stakeholders who shared insights through interviews, discussions, and reviewing and comments on drafts of the paper. In particular, the team thanks Miguel A. Amutio Gómez of the Government of Spain; Samantha Bansil of the OECD Global Blockchain Policy Centre; Rafael André Pestana Belchior of Técnico Lisboa; Perrine de Coëtlogon and Albane Sautory of the Government of France, Savvoula Kotsi and the Ministry of Digital Governance of the Government of Greece; Frank Leyman of the Government of Belgium; Alex Lim of the Government of Singapore; Barry Lowry of the Government of Ireland; Johan Magnusson and Livia Norström of the University of Gothenburg, Sweden; Tiago Mendonça of the Government of Portugal; Andreas Nilsson of Spring AB, Sweden; Vera Soares of the Government of Luxembourg; Renske Stumpel of Groningen Municipality, Netherlands; David Suomalainen of the Government Offices of Sweden; Andrew Woolf of the Government of Australia; Participants of Scancor Weatherhead seminar, Scancor-Weatherhead partnership, Harvard University, United States; and the participants of Informatics seminar, Applied Information Technology, University of Gothenburg, Sweden.

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Executive summary

Blockchain and its underlying distributed ledger technology have the potential to fundamentally transform a wide range of industries and markets. However, so far, blockchain hype has often led public sector organisations to approach the technology with both uncertainty and unrealistic expectations, as such inflated expectations often overstate or obscure practical applications. Previous OECD work such as *Blockchains Unchained: Blockchain Technology and its Use in the Public Sector* (https://oe.cd/blockhain) and *State of the Art in the Use of Emerging Technologies in the Public Sector* (https://oe.cd/et-gov) have outlined the core blockchain technologies and their use cases and policy considerations for the public sector. Despite hundreds of pilots, there have been few government success stories related to blockchain implementation. Scepticism and cynicism are on the rise as this technology appears to be entering the proverbial "trough of disillusionment" common among emerging technologies as they inch towards maturity and a fuller understanding. This scepticism must be taken seriously and investigated in more detail to determine the extent to which it is warranted, and whether, when appropriate, it can be mitigated.

The OECD Observatory of Public Sector Innovation (OPSI) (https://oecd-opsi.org) and the Digital Government and Data Unit (https://oe.cd/digitalgov) have coordinated the development of this paper, which seeks to outline the current state of blockchain in government. It provides an overview of early projects, describes the observed beliefs and sentiment among the government actors, helps officials decide whether blockchain may be worth pursuing, debunks some commonly held misconceptions, and focuses on a set of examples and case studies that provide useful lessons and early observations about factors that have and can contribute to whether blockchain efforts are successful or unsuccessful, both at the project and organisational levels.

In doing so, the paper seeks to cut through the hype around blockchain, equip public sector decision makers with a better understanding of the current blockchain landscape, help officials take a critical look at potential use cases, and to assist them in their thinking as they consider, and if appropriate, initiate, manage, and de-risk blockchain technology projects. These steps can ultimately help future public sector blockchain implementations to succeed and reach their full potential.

This report is not an introduction to blockchain technology or its use in government. Despite aiming for a jargon-free report, readers are expected to understand the fundamentals of blockchain technology. Users who are interested in learning more about the technology can find overviews and guidance in the papers mentioned above. However, we recommend that the reader return to this report for an update after reading up on the fundamentals.

To aid in blockchain project success, this report explores the following questions and provides illustrative examples based on early reports and research:

- Is the *blockchain solution* viable, valuable, and vital for a particular service? (Chapter 1 Introduction)
- Does a *decision maker* have enough general knowledge and realistic expectations related to blockchain? (Chapter 2 Ten myths about blockchain in the public sector)

- Does the *project* take into account factors that lead to success and failure? (Chapter 3 Blockchain project success and non-success factors)
- Is the *organisation* digitally mature and blockchain-ready? (Chapter 4 Organisational and team success:)
- *Summary:* How to drive a successful blockchain innovation project. (Chapter 5 Conclusion and recommendations)

Chapter 1 “Introduction” provides an overview of the current situation and an overall framework to evaluate the benefits of blockchain services for a particular need using the three Vs (viable, valuable, and vital) checklist as applied to blockchain and associated use cases. Chapter 2 Ten myths about blockchain in the public sector lists common misconceptions and debunks commonly held myths about blockchains in the public sector to help the reader navigate this terrain. For instance, it dispels misconceptions that blockchains have served as a disruptive force in government, that blockchain can be applied as a general technology, and that users even care in general that a service uses blockchain.

Chapter 3 “Blockchain project success and non-success factors” discusses factors underlying project success and non-success at the project level. For instance, research and OECD observations have identified a clear value proposal, a pre-determination that blockchain is the most appropriate technology for a task, and a focus on end users as success factors. Conversely, a high level of disruptiveness in an attempted project and an uncertain legal landscape are key contributors to projects falling short of expectations.

Chapter 4 “Organisational and team success: ” approaches the suitability and implementation of blockchain to improve public sector policies, processes and services. The chapter starts by presenting the building blocks that help governments develop digital maturity to make good decisions about the use of a given technology. This chapter assesses how the digital maturity at organisational and at team levels influences the success, or otherwise, of blockchain enabled delivery of various services.

Chapter 5 “Conclusion and recommendations” summarises the key findings of the report, and a series of appendices provide additional information. Appendix A focuses on case studies, including blockchain success stories as well as a discussion on problems projects have faced. Appendix B provides a longer list of potential use cases, focusing on projects that were able to proceed to the point where people began using the service.

Finally, it is important to note that the findings of this paper are based on early evidence and often—admittedly—anecdotal observations and analysis of successful and unsuccessful blockchain initiatives. Given the early nature of most government blockchain projects and the little amount of research focusing on public sector use cases, it is not yet possible to draw empirical evidence from a long list of uncontestably successful of failed public sector blockchain projects. However, the authors hope that this paper can serve as a step towards this goal.

1 Introduction

Governments are rapidly moving to achieve digital transformation by using more digital technologies and data to create open, innovation-rich, efficient, and effective public sectors.[1] Therefore, governments are continuously rethinking their role and exploring novel technological opportunities.

One of the most discussed approaches is blockchain, which promises a move toward decentralised computing and transparent and accountable processes; a shift from siloed architectures; and a way to empower individuals and peers through technical means. More radical promises include visions of cutting out government and third-party middlemen, providing automatic trust or minimising the need for governance.

For all public sector blockchain projects, someone always asks, “But why do you need blockchain for that?” Decision makers who have presented blockchain technology seriously to an interested or critical audience have learned to provide answers to this question.

One answer is that clear business needs make blockchain technology a suitable and optimal candidate for the use case. The applicable blockchain attributes include the following (all examples are described in more detail in Appendix A)[2]:

- increased transparency of logs or workflows or smart contracts (see Swedish Lantmäteriet or Netherlands Groningen Stadjerspas)
- data integrity and immutability (see Estonian RIA)
- cutting out a specific third party (see Malta BlockCerts)
- decreased cost for a specific service (see US Voatz)
- providing an entirely new type of service (see Israel’s local currency project or the Swedish unemployment agency project)

However, the question about the need for blockchain is difficult on a more general level. Part of a full answer would include the statement, “We do not fully know yet.” This is especially true for public sector applications. We cannot yet draw empirical evidence from a long list of uncontestably successful public sector blockchain projects. This is also the reason why the results of this report should be seen as preliminary and case selection as illustrative and somewhat anecdotal.

[1] OECD efforts to support governments in achieving digital transformation are led by its Digital Government and Open Data Unit (https://oe.cd/diggov), in coordination with the OECD Working Party of Senior Digital Government Officials (E-Leaders; https://oe.cd/eldrs). This work is guided by the OECD Recommendation on Digital Government Strategies (https://oe.cd/diggovstrategies). Innovative applications of technology solutions, such as blockchain, are studied by the OECD Observatory of Public Sector Innovation (OPSI; https://oecd-opsi.org). OPSI serves as a global forum for public sector innovation, helping governments to understand, test and embed new ways of doing things through the application of fresh insights, knowledge, tools and connections.

[2] Please note that some of the example projects have benefits that belong to several categories. For example, Stadjerspas also eliminated third parties and aimed to cut costs.

Instead, we have a technology that has disruptive potential, a series of proven use cases mainly from the private sector (many of which are linked to cryptocurrencies, fintech and other financial services, areas in which blockchain's benefits seem different from most potential public sector use cases[3]), and anecdotal evidence from a number of early technology projects for which blockchain can be used for interesting new approaches or services that match public sector requirements (see Box 1.1 for one example).

Box 1.1. Information Systems Authority, Estonia

One early example of a blockchain-backed public service comes from Estonia. The Estonian Information Systems Authority (RIA) uses KSI blockchain, a permissioned blockchain solution. KSI blockchain guarantees the data integrity of public services by providing immutability guarantees of stored data via blockchain-backed records for integral government services, such as the succession registry and health registry. The main benefit of this solution is storing checksums (the hashes) of critical data in an immutable way. More discussion about this example use case can be found in Appendix A.

Source: https://e-estonia.com/solutions/security-and-safety/ksi-blockchain.

There is clear evidence of rapidly developing technology and better tools for providing project support (see Box 1.2 for description of The European Blockchain Service Infrastructure), but also an abundance of projects that fall short of actually serving citizens and other end users. While this is not uncommon with new technology, it points to the challenges in leveraging blockchain in government.

Box 1.2. European Blockchain Service Infrastructure (EBSI), EU

Globally, there are several infrastructural projects that aim to build capacity, connect relevant stakeholders and ultimately support public services. These initiatives include, for example, the Chinese Beijing Municipal Blockchain Blueprint initiative (https://link.medium.com/hMYZHDgnR8). The purpose of this initiative is to improve government processes and services by assembling previously scattered expertise in the relevant areas into a common distributed core infrastructure.

The flagship European initiative, European Blockchain Service Infrastructure (EBSI), is a joint initiative of the European Commission and the member states (operating collectively as the European Blockchain Partnership). The stated aim of the initiative is to deliver EU-wide cross-border public services using blockchain technology. EBSI is fully compliant with EU law in terms of privacy, cybersecurity, interoperability, and energy efficiency.

EBSI is organised into a network of distributed nodes with applications focused on specific use cases. Four use cases were selected initially in 2019 and different prototypes were built to address each case. The four blockchain use cases selected are notarisation, diplomas, self-sovereign identity, and data sharing.

[3] There are interesting initiatives involving central banks, digital currencies and blockchain technology regulation, but these discussions are mainly omitted from the scope of this report.

- The Notarisation use case is focused on creating audit trails, automatic compliance checks and proving data integrity.
- The Diplomas use case involves consent management related to access to educational credentials, cost reduction for verification and increasing diploma credibility.
- The European self-sovereign identity use case gives users the ability to create and control their identity credentials.
- The Trusted Data sharing use case provides a means for secure data sharing among customs and tax authorities (esp. related to VAT identification and imports).

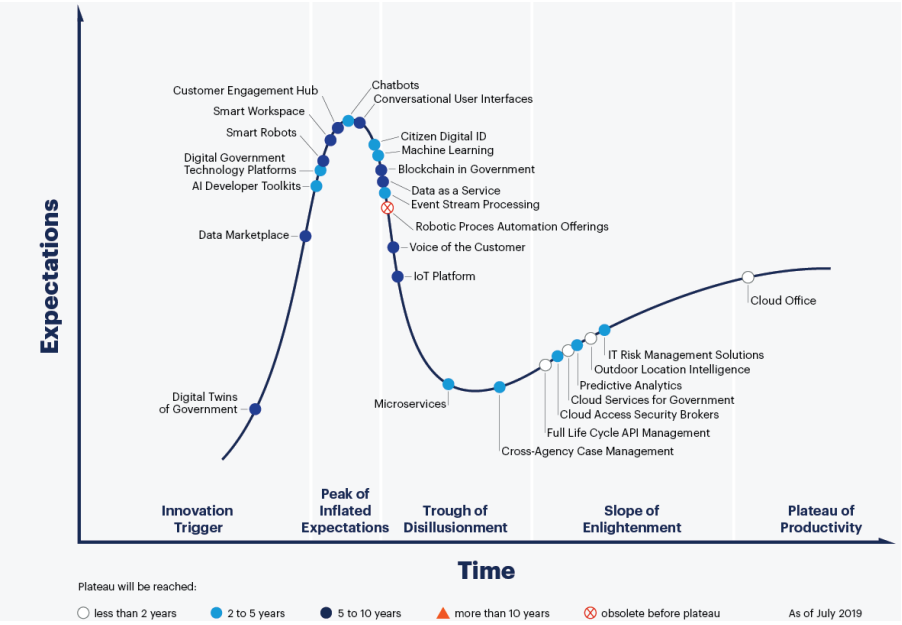
There is a wealth of material available about the different use cases, including necessary implementation software, specification and service support available. Additional use cases are being added, and current applications are being rolled out at the time of writing this report.

Source: https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/EBSI.

Cutting through the blockchain hype

Gartner's (2019[1]) Hype Cycle for Digital Government lists blockchain as an important emerging technology for the public sector (Figure 1.1). However, Gartner recognises that disinterest and disillusionment in blockchain technology is increasing; only 7% of respondents said they have deployed blockchain or will do so in the next 12 months.[4]

Figure 1.1. Gartner's Hype Cycle for Digital Government Technology (2019)



Source: https://blogs.gartner.com/smarterwithgartner/top-trends-from-gartner-hype-cycle-for-digital-government-technology-2019).

[4] This still seems to be a rosy picture of the situation going into 2020 (the time of writing), and most of the projects are likely closer to 12 months away from going live rather than full deployment.

Any technological invention is met with a certain level of hype and unwarranted expectation, which is an important part of how various technologies are diffused in a society. Swanson and Ramiller (1997[2]) provide a theory of this innovation diffusion process and the role of expectation and hype. First, novel technologies are introduced in technology-focused press, publications, and tech reports (now also blogs), followed by tradeshows. Then, the topics move to consultancy reports and to industry organisations, public authorities, standards committees, and so on. Finally, novel technologies are discussed by mass media and in popular publications. At some point, officials in public and private organisations entrusted with monitoring novel technologies discover the technology's potential. They then gather information and engage in experimentation efforts to determine whether the novel technology would be useful to a specific organisation and its applications. Experimentation can be organised as internal development projects and different kinds of pilots. Ultimately, technologies will find their way into strategies and acquisitions and everyday use—provided they are found to be useful for the organisation. Normally, the hype fades as the innovation matures and becomes mainstream, which seems to be the current situation with blockchain. However, unwarranted expectations and various misconceptions detrimental to the deployment of blockchain in organisations are common.

Hopes for and hype around blockchain make it a tricky area for research: It is much easier to find reports about project launches and lofty plans rather than the actual deployment for the end users of the service…or about when plans are scrapped altogether. However, this does not mean that projects would be impossible to carry out, but rather that marketing efforts are more often focused on the beginning of the project lifecycle. Blockchain enthusiasts developed early on an impressive blockchain-focused digital media landscape, including sites, blogs, podcasts, etc. that have excellent reach for those who are interested in staying updated on developments in this area.[5]

Early public sector projects in particular received heightened media attention when they were launched. One entrepreneur who developed an early blockchain start-up operating in the public sector context confessed in our research that his start-up was entirely unprepared for the press it received when the first concepts and parts of the pilot were released. When kick-off presentations, based on mere mock-ups, are televised nationally it sets very high expectations on a project.

Box 1.3. Early public sector distributed ledger efforts

The history of blockchain begins with the publication of a Bitcoin white paper in 2008. However, the Estonian RIA's blockchain-backed technology had already been developed prior to this. Initial versions of the succession registry were running in 2012, then called hash-linked time-stamping. Some blockchain enthusiasts would thus not consider this technology a blockchain service due to this timeline and because it does not store data on blockchain (only hashes that provide the integrity of the underlying data); instead, they would call it a blockchain-based service. Nonetheless, the service relies on blockchain solutions, has been running for a number of years, and has gathered a large number of users to secure the integrity of data. More discussion of this use case can be found in Appendix A.

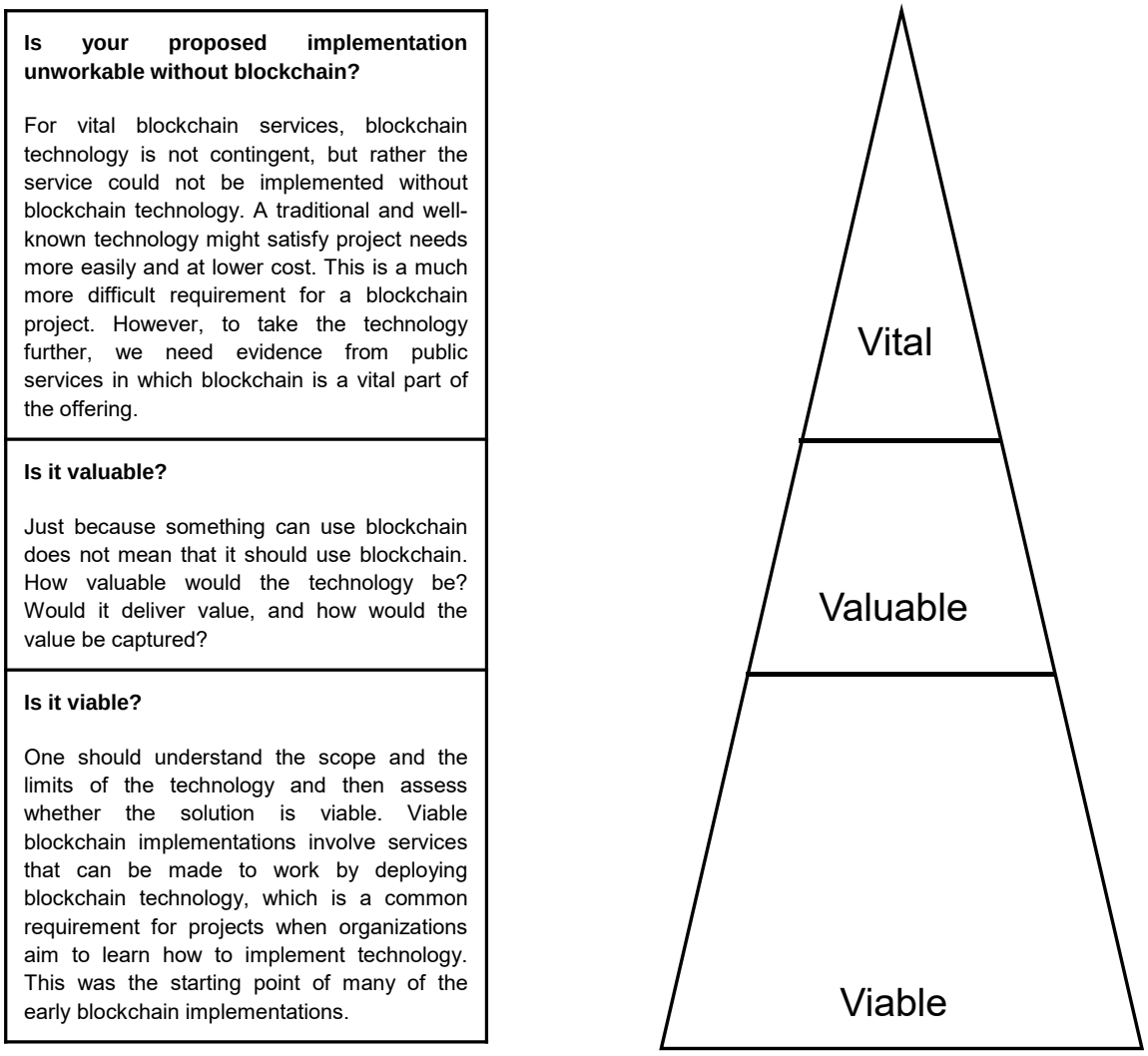
[5] For example, see https://www.coindesk.com.

Blockchain: viable, valuable, and vital?

The OECD's Observatory of Public Sector Innovation (OPSI)[6] (Berryhill et al., 2019[3]) previously reported on a checklist of emerging technological adoptions, including the three Vs (viable, valuable, and vital) originally suggested by Deloitte. Three Vs were originally suggested for cognitive technologies such as artificial intelligence, we have also found them to be appropriate and useful for analysing blockchain use cases, and we adapted them to generate considerations for blockchain use cases (Figure 1.2).

The framework has three levels. At the *viable* level, blockchain is a viable solution for a service. The second level measures *value*. If blockchain is valuable for a service, then clear benefits exist. The third and highest level is the degree to which blockchain is *vital*. At this level, blockchain is a 'must' for a specific service, because it has unique properties aligned with the needs of the service.

Figure 1.2. Is blockchain vital for your use case?



Source: OECD, as adapted from https://www2.deloitte.com/us/en/insights/deloitte-review/issue-16/cognitive-technologies-business-applications.html.

[6] https://oecd-opsi.org.

Any potential blockchain service can be analysed using this checklist. This report strives to better understand the third category, *vital.* Blockchain solutions at this level are evidence of a technology's full potential, and so long as the project concept is sound it can be considered to be viable and valuable…but is it really vital? Box 1.3 uses an example to illustrate how to determine the level—viable, valuable or vital—of the project.

Box 1.4. Understanding the Three Vs in action

The Estonian RIA's blockchain-backed system is currently used for a large number of government services. However, different services use the underlying infrastructure in different ways. For some of the use cases, blockchain-backed integrity solutions (which rely on timestamped hashes) are a complement to other, more traditional database-driven solutions. The choice between these technologies is made by the public organisation's decision makers, based in part on security and integrity requirements and other business needs for the service. In this example, blockchain-based solutions are thus viable, valuable, and vital, for ensuring information integrity by using immutable timestamps. As such, immutable timestamps are a core competency of blockchain technology. However, these requirements were not met for some of the other business needs, thus making more traditional solutions a better option for some of the services.

2 Ten myths about blockchain in the public sector

Technological breakthroughs are often—some would claim *always*—accompanied by unwarranted expectations and hype (Swanson and Ramiller, 1997[2]). This is not necessarily a bad thing: Imagining the potentials of technologies helps to make the possible use cases more concrete.[7] Thus, blockchain is no exception in terms of hype, but public discussion around blockchain is still often full of various kinds of inflated expectations about what the technology is and what it can do.

Unwarranted expectations are especially risky if the technology is still emerging. For professionals who want to understand and pursue the use of the technology in their organisations, it is difficult to separate the hype from the actual solution. Many are then left disillusioned about the promises of technology. This problem increases when it is difficult to distinguish facts from marketing statements related to earlier projects and their outcomes. It is important to discuss the warranted and unwarranted expectations and assumptions related to the technology. Making these assumptions visible helps to de-risk specific projects and clarify the promise of blockchain for the public sector.

Research conducted for this paper and the experience of the OECD Digital Government Unit and OPSI in working with governments around the world have shed light on a number of recurring myths related to public sector blockchain. These myths are not always voiced in exactly these ways, but communicated as unspoken assumptions. The purpose of this chapter is to clarify the discussion and reduce the amount of ambiguity and confusion surrounding the technology and to provide clarity on myths we have observed. Box 2.1 lists the 10 myths that need to be clarifies in this area.

Box 2.1. Ten myths about blockchain in the public sector

1. (Public) blockchains are disrupting the public sector all around the world.
2. It is impossible to build successful blockchain applications for the public sector.
3. There is one obvious way to apply blockchain technology in the public sector.
4. If you build it, users will come.
5. If it is blockchain, it needs to be big and disruptive.
6. Nobody knows how blockchains are implemented.
7. Blockchain is a generic technological solution, like AI.
8. We are not tech people and should not care about detailed design decisions like blockchain.
9. Results of blockchain projects contribute to blockchain knowledge.
10. Users care that services are based on blockchain.

[7] On the importance of blockchain experimentation, see Du et al. (2019[12]).

Myth 1: (Public) blockchains are disrupting the public sector all around the world.

Industry and public press, consultancy reports, and vendors have distributed information about early adopters and experiments that makes it seem as though a huge public sector overhaul toward blockchain is happening all over the world and at all levels of government[8]. This sometimes implies that "everyone is already using blockchain," and if nothing is done then a government institution will somehow lag behind.

This is not the case. Many countries and municipalities have looked into the technology, and many have developed ideas and proofs of concept. Some have tested these ideas, but so far, according to our research, ***blockchain public services that have actual users are rare.***

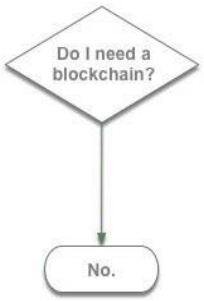
Although this kind of major overhaul could take place in the future, so far, there is scant evidence indicating that large-scale transitions are underfoot.

We are seeing pioneering cities, countries, companies, and international collaborations conducting interesting experiments and collecting valuable knowledge. We are also observing increasing maturity level of the technology and supporting infrastructures for adoption. However, the press makes more noise when something is launched than when it is terminated or simply fizzles out. Thus, we are witnessing many projects fade into the background when they do not achieve their initial goals and their funding runs out.

Myth 2: It is impossible to build successful blockchain applications for the public sector.

A traditional internet joke about blockchain is related to a simple graph of its use that asks, "Do I need a blockchain?" with a single arrow pointing to a box that says, "No."

Figure 2.1. Common joke about blockchain



Source: Meunier, (2016[4]), *When do you need blockchain? Decision models* (https://medium.com/@sbmeunier/when-do-you-need-blockchain-decision-models-a5c40e7c9ba1).

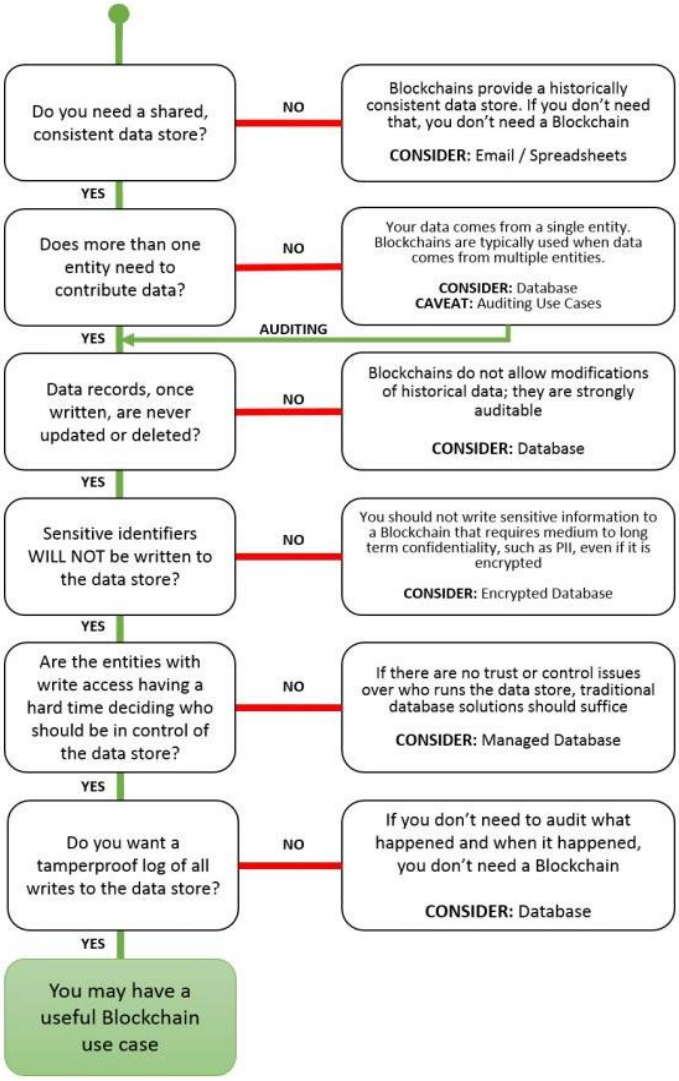
The joke means that other, better ways always exist to accomplish a specific task or fulfil a need without resorting to blockchain technology. While amusing, this is often not a deep enough answer for a person wanting to take a technology seriously and make informed comparisons against other relevant technologies. In many cases, there are legitimate alternatives to blockchain and weighing the benefits of the technology to the specific use case is very important.

[8] For an early counterexample, see Furlonger and Valdez (2017). For a more recent review that raises this same concern, see Allessie et al. (2019).

Fintech firms and other private organisations have successfully implemented blockchain solutions and attracted users. The most traditional application of blockchain is Bitcoin and other cryptocurrencies. Despite Bitcoin's issues with energy use, performance, and speculative uses, this application has a genuine user base and value-generating potential. Initial coin offerings (ICOs[9]) have provided actual crypto-funding for a number of companies that have developed services despite problems related to scamming, etc. Another group of successful use cases relates to permissioned chains in the areas of supply chain management and provenance.

For example, the U.S. Department of Homeland Security (DHS) Science & Technology Directorate (Yaga et al., 2018[5]) published a flowchart (Figure 2.2) to help one determine whether a blockchain may be needed for a development initiative. It lists several important characteristics offered by the technology.

Figure 2.2. DHS blockchain technology evaluation for development initiatives



Source: Yang, et al, (2018[5]), *Blockchain Technology Overview*.

[9] ICOs are a form of crowdfunding using cryptocurrencies. Early ICOs were often scams or speculative investments, which led to demands to regulate them. Different governments have taken different approaches to their regulation.

Even though public sector organisations and public services in general have specific characteristics, ***there is no particular reason***, if it can be used in other contexts, ***why the public sector could not develop, implement, and use*** services powered by blockchain. The public sector is often seen as an important partner in developing and diffusing technology, if not as a driver of technological change in society.

The public sector also provides a number of services that could lend themselves to blockchain experimentation and implementations (e.g., different kinds of notarisation services, government-backed voucher schemes, and identification). More specifically, some tasks that blockchain can support are carried out at least in part by the public sector, such as health care, education, and culture. Appendix A lists successful blockchain projects that deliver value to citizens.

Myth 3: There is one obvious way to apply blockchain technology in the public sector.

One argument originally pushed forward in the Bitcoin context is that *"We [Satoshi Nakamoto] have proposed a system for electronic transactions without relying on trust."* The idea of transactions being carried out in a peer-to-peer network and in a more transparent way would provide technical trust mechanisms to the users, which would mean that a layer of technical trust would also add institutional trust to the transaction. That is, actors would not need to trust a centralised computing entity but would instead trust the network that carries out the transactions in a transparent and immutable way.

For many public sector actors, adding trust to the equation by notarising, guaranteeing earlier transaction histories, and providing identity would primarily mean that they are disintermediated: the actor would no longer be needed to provide the infrastructure or authority for the transactions carried out in this new network.

Several assumptions in this story are not convincing:

- One of the key assumptions is related to trust, especially in the context in which a technical solution (blockchain) complements or replaces an existing trust related to an institution. This process is not straightforward and leads to a novel trust configuration that might have unintended consequences. For example, if one of the cryptocurrencies, such as Bitcoin or Facebook's Libra, were the primary way to conduct payments globally, then it would have direct high-level effects on the control over monetary supply and fiscal policy—a role many governments are unwilling to relinquish to either of these actors. Other examples apply to many centralised government processes.
- There is a second assumption related to replacing trust in government with trust to specific technology. Governments are continually tested and need to earn the trust conferred to them via democratic processes, not only through technical means. Government accountability and transparency, the rule of law, the right to due process, and other fundamental rights are all part of this process in which a mandate is tested and delegated to public sector actors. This is currently a rather centralised process, and it is unclear what the impacts would be of adding technical trust to this process via more decentralised technology such as blockchain.
- The third assumption is that many of the transactions stored on the chain would be relatively isolated events such as one payment transaction in Bitcoin that can be captured and represented digitally in a meaningful way. This could hold for many transactions (e.g., private rating systems, such as Yelp or Airbnb, or public service transactions such as a change in a person's unemployment status or ownership of specific property)[10]. However, some other processes are much more complex and deserve consideration. For example determining whether someone is an active job seeker in the job market or if there are several legal claims to a specific property.

[10] Appendix A shows examples from the Swedish Lantmäteriet land registry or the Swedish unemployment agency.

- The fourth key assumption is the role of the public sector in the economy. Issues of private and public production of services always have political elements. One question has to do with the nature of service: whether services are offered to citizens to guarantee basic rights and equity versus to customers based on a specific need and compensation in open markets.[11]

When investigating how public sector actors are actually engaging with the current technology, it has little do to with these high-level considerations. Instead of one focus on disintermediation, there is considerable variability among organisations, projects, use cases, and services (as can be seen in Appendix A and Appendix B).

Believing there is only one way to engage with blockchain technology is limiting. It seems that a less centralised computing technology ***could bring benefits in a number of areas*** instead of one, and different actors in the public sector are pursuing these projects and initiatives.

Box 2.2. Differing levels of disintermediation in government use cases

Some use cases, such as notarisation, have much to do with replacing incumbent technology with a blockchain-based technology while others, such as Stadjerpas (a city pass voucher scheme, described in more detail in Appendix A), are unrelated. The Stadjerpas pilot solves the problem of digitalization of vouchers and relies on individuals for consent concerning their data management. Other pilots involve developing and promoting entirely novel innovations, such as use cases related to municipal identity provision. They use the technology, for example, to solve information integration issues or use transparency to work around public service information-sharing siloes, rather than trying to disintermediate certain aspects of the role of government.

Myth 4: If you build it, users will come.

Providers of public services should never lose sight of what the technology and the solution it provides mean to the end user and whether they will be able to use and adopt the service. This is not always the case for digital technologies: for many of these technologies, early proponents have often been voluntary, developer-oriented communities that have embraced open source software practices. One particularly relevant example of this is the Linux operating system and more recently Bitcoin and Ethereum open source projects. A high level of technical expertise is needed to develop the technology in the early stages of the technology lifecycle. Research on open source projects shows how this can lead into organisational structure, where early in the project the primary focus is on the technology (“meritocracy”). Users are only taken into greater consider when the project grows. To build a large user community, democratic participation mechanisms and inclusion of participation are important (for more thorough discussion see (O’Mahony and Ferraro, 2007[6])). Many of these virtual internet communities follow the power law of contribution (20% of users are responsible for 80% of contributions, which is even steeper in some communities). In the past, many of these communities were often based on the unsustainable idea of a

[11] Traditional distribution of moral labour in Western societies starts with the assumption that public and private spheres of society co-exist and complement each other but have different aims and logic. If blockchain dramatically alters this division of moral labour on a large scale in a society, then this will likely be resolved in the political arena. An additional hurdle relates to the mandate of public actors in the production of public services that is protected by institutional legitimacy.

genius super-coder, who almost singlehandedly takes care of the development of a technology[12]. In this kind of scenario, there is a risk that more emphasis is put on coding and less on tasks that are seen as more mundane, such as documentation, user testing, usability, or marketing in general.

There might be some benefit in focusing on and attracting talented developers who are highly interested in technology to participate in the early phases, but if these other tasks are neglected, then it is a recipe for failure when the product or service is released later, because talented developers form a very different user pool than average users.

It might even be assumed that, because a specific technology has some superior qualities, it will automatically be adopted and become popular. This relies on an assumption that it would be the users' mistake not to adopt the better technology immediately, despite its possible flaws or drawbacks. Some technology proponents are highly engaged with a specific part of the technology and portray, for example, blockchain-based services as radically different—and better—than traditional services built using other technologies. This is a dangerous assumption: users always need to be convinced about the merits of the services they use.

Thus, ***users need to be made aware of the benefits of the services.*** Technological superiority is convincing to some users, and gaining the first critical users (i.e., early adopters) might make or break a technology product. Broader design, development, and marketing efforts are needed that take into account users' needs and clearly communicate the benefits of the technology for public services.

Myth 5: If it is blockchain, it needs to be big and disruptive.

Several early books, such as the one by Tapscott and Tapscott (Tapscott and Tapscott, 2016[7]), herald blockchain as a disruptive technology, blowing the expectations of blockchain's effects out of proportion. This is exciting. Indeed, blockchain is a radical departure from centralised computer engineering that has been the primary paradigm in computing for more than four decades. The technology offers a rare glimpse of a fundamentally different way of thinking about decentralised services.

This sets the level of expectation quite high for services built on this technology. Disruptive and revolutionary services can be very complex and difficult to put together as projects. More evolutionary projects, perhaps especially so in the public sector, might more easily gain institutional legitimacy and pose less risk of running into institutional obstacles, inertia, and other often valid concerns. For example, blockchain might provide a more transparent time-stamped logging algorithm for a specific workflow. However, despite this being the correct solution for the pilot, it might not be disruptive enough to live up to the expectations of revolutionary change stakeholders.

Increasing service complexity coupled with increasing technological complexity makes large, disruptive projects exponentially more difficult to manage—and successfully achieve. On the other hand, smaller projects do not seem to answer to satisfy sky-high expectations. We believe this dynamic is a real problem for many public sector projects. When projects do not meet expectations, it is interpreted as the fault of the project. When projects succeed by using more evolutionary and iterative approaches, they are no longer seen as blockchain.

[12] In the last ten years or so, open source movements have rejected these calls for meritocracy. See for example Post-meritocracy Manifesto (https://postmeritocracy.org).

Box 2.3. Determining an ambition level and risk appetite

Determining a project's level of ambition and risk appetite is very important. More evolutive approaches might not lead to revolutionary services but are probably easier to manage technology projects. For example, in the voting use case (Voatz in Appendix A), blockchain could be used in the time-stamped vote archive, but voter identification, voter registration, and vote counting could be done using other and possibly more suitable (e.g., better understood, easier, cheaper, better fit) technologies. Blockchain could also be a small subset of services; for example, the distance voting service, described in Appendix A, is not automatically intended to replace all voting but was rolled out as a complementary distance-voting app for U.S. service members overseas.

In our empirical work, we have identified several ways public sector actors discuss blockchain technology. Some of these discourses are more philosophical, and some are more pragmatic and evolutive, approaching blockchain as though it were a tool like any other. Both practical and philosophical arguments can even appear in the same discussion, which can be both confusing but also an accurate way for individuals to articulate what this technology is able to accomplish in the context of their organisations.

This discussion actually has played out in relation to other earlier technologies in computing, such as when free software advocates debated against open-source software enthusiasts.[13] The former wanted to focus on software freedom, whereas the latter were keen on be being seen as having a business-friendly, credible agenda and pragmatic approach.

We strongly believe that ***small, pragmatic, and iterative blockchain implementations are just as valuable***—blockchain does not have to reinvent the whole public sector.

Myth 6: Nobody knows how blockchains are implemented.

Public sector actors often need to reach out to their technology providers from the private side. This poses problems that are well known to public sector procurement professionals. If the expertise is acquired from external sources, the public sector responsible for the delivery of the service needs to know what technology to buy. This requires careful evaluation of the business need for the blockchain-based service (see earlier discussion about whether service is 'vital'), knowledge about the public procurement or commissioning process, and careful evaluation of the vendors of the specific blockchain-based service.[14]

One of the early problems related to blockchain involved public employees' lack of technical skills in the area. Even though work has been carried out over the years in computer science and software engineering, most development efforts have concentrated on the development of more centralised computing architectures and data storage solutions.[15]

The lack of technical skills is not the main hurdle anymore. ***Technology and corresponding skills have been developing rapidly over the last few years.*** This is both true in the public sector to an extent, as well as among private sector vendors that public officials can access (e.g., through partnerships or

[13] See, for example, Weber (2005[36]).

[14] See also Myth 8. "We are not tech people and should not care about detailed design decisions such as blockchain."

[15] For example, LinkedIn selected blockchain as the No. 1 "hard skill" sought for 2020.

procurement). Although a blockchain skills gap remains, more resources are available, and there is much infrastructure to support developing these projects. There is a wealth of expertise collected from early innovation projects, as well as an increasing number of potential vendors able to provide the services.[16] This means for public sector actors that technology is mature for deployment, but obstacles for large-scale implementations in the public sector more often have to do with identifying relevant use cases and user needs where use of blockchain technology is vital.

Myth 7: Blockchain is a generic technological solution, similar to AI.

Comparing various emerging technologies for public sector use is always challenging and often not useful: The factors that are easy to measure related to technologies are related to publicity or funding decisions. However, these are not very good measures of technological capability or maturity. For example, AI has been a hot research topic for a very long time, whereas blockchain interest has peaked in the last 10 years or so. For AI, several areas of use cases have been found, where the merits are uncontested.[17] For blockchain, the jury is still out.

Limits of the blockchain design space are still unclear (Lindman, Tuunainen and Rossi, 2017[8]); however, the technology is much more specific than, for example, AI. Therefore, although quite a bit of discussion occurs around which areas could be used (basically using AI to solve any work task that requires automation), ***the uses for blockchain technology are much more limited in their scopes***.

This means that the deployment of the technology is different: Many current services might be able to benefit from AI, whereas blockchain technology sets many more constraints to the service. For example, a use case needs to benefit from increased transparency or immutability or some of the other technical characteristics. Although not all blockchain technologies have all of the various attributes (primitives), common design characteristics, such as decentralization, irrevocability, pseudonymity, tokenization, and mechanism designs, afford interesting use cases but pose real problems for other use cases. These problems are not only technological but also related to the influence their use has on social and institutional contexts.

There is also considerable variability in the generic solutions blockchain offers. For example, Ethereum offers a generic developing environment for applications. On the other hand, Bitcoin was initially intended only for payments (and mining).[18]

Myth 8: We are not tech people and should not care about detailed design decisions such as blockchain.

The modular layering of the innovation approach has become very important recently, which means the different layers of technology (e.g., device, network, and digital service) are logically separated in a way that enables design decisions to be taken separately in one layer without the decision affecting other layers (Yoo, Henfridsson and Lyytinen, 2010[9]). This enables faster innovation inside these logical units. In this same vein, some organisations claim they are blockchain agnostic, which means they decouple design

[16] See, for example, Allessie et al. (2019[18]) for an overview.

[17] For more discussion on this, see Berryhill et al., (2019[3]).

[18] For Bitcoin, more uses have sprung up, only after the network was established, related to time stamping, storage, and so forth, but the uses are still constrained by initial designs related to payments.

decisions from any specific blockchain implementation. Usually the agnostic design on a platform can then be implemented using several blockchain solutions.

Similar logic is often at play when public organisations follow public procurement rules: The specification of requirements and other design decisions are decoupled from implementation details, which could mean most of the design capability is on the vendor side.[19] However, for many, especially more disruptive, blockchain implementations, this seems to leave the public organisation at arm's length from the implementation details, and the devil can be in the technical details of blockchain.[20]

Decoupling design from implementation does not seem warranted. Current software development practices stress the importance of being close to the end user to understand their needs and being able to include them in development. The idea of separating requirement specifications from implementation details seems to indicate a problematic waterfall-like process. Instead, different agile and iterative approaches are seen to be of key importance to the relevant stakeholders.

Another caveat is that if design could be separated entirely from implementation, then these technology projects could use any fitting technology—not only blockchain—to answer a specific requirement or business need identified by a public organisation. We have seen empirical cases in which this has actually taken place and organisations have replaced blockchain with more traditional database approaches (see Appendix A for an example).

Several infrastructural initiatives such as EBSI in Europe aim to provide reusable components and infrastructure that would make it possible to design blockchain-based solutions that rely on this infrastructure, which is complemented with supporting services.[21]

Myth 9: Results of blockchain projects contribute to blockchain knowledge

Everyone would like blockchain technology projects to succeed. However, when initial blockchain projects fail—and they often will not reach their goals—it is important to learn from the projects. This is the approach many private organisations take to build internal blockchain technology-development projects or programmes to learn more about the uses of technology. Sometimes projects are announced through press releases, but when the projects run into trouble, the trouble is often obfuscated, and the projects just seem to disappear and fall from the face of the Earth, or worse, continue operating even if they should have been eliminated.

Although the limits of institutional memory and amnesia are quite understandable for organisations and individuals engaged with the technology, we believe this poses a larger problem for learning about how organisations are using the technology. If the projects then failed, they were quickly forgotten. Everyone would like the projects to succeed and be transformed eventually into useful services. However, organisational learning is also an important product of early pilots. Thus, early ***experimentation is important, but the lessons should be shared*** so that everyone does not try to reinvent the wheel.

[19] See also Myth 6: "Nobody knows how blockchains are implemented."

[20] One of our respondents also noted that details of the code could be considered a "secret part of a business model" by the vendor. Thus, the one who is running the public procurement has a responsibility to procure in a way that allows the procurer to understand how the service works and does not result in parts of the public service being locked-in by a specific vendor.

[21] See https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/Get+Started+EBSI for more details on the initiative and infrastructure.

This problem is exacerbated if there is simultaneously unwarranted hype about blockchain potential in press while local experiments with the technology fail, which creates a very difficult dynamic for those responsible for blockchain projects and for those wanting to engage with this technology.

Myth 10: Users are interested that services are based on blockchain.

Sometimes proponents of a specific technology think that others are as interested in it as they are. This attitude has roots in developers collectively thinking that users are just as adept at using technology as they are and that technical greatness would automatically translate into users taking specific technology into use "because it is better."[22]

This is not generally the case. However all other things being equal (e.g., equitable decisions, privacy of personal information, etc.), ***most end users of services do not generally care much (or even know) which technological infrastructure provides them with a service.***[23] Most users will not value blockchain-based implementation over implementation conducted using some other technology. In fact, when it comes to blockchain, many people may have an additional element of distrust in blockchain that may need to be overcome.[24] It is important for the public sector actor to understand users' needs and then convince them that blockchain is valuable and provides something necessary.

However, some groups of users are interested in technology, especially among cohorts of early technology adopters. For these groups, the attributes of the technology play important roles. For some users, the benefits of blockchain may prove to be important. For example, privacy protection or open-source software security are important for specific end-user subsets. Public sector services might also rely on key stakeholders (usually other public or private organisations) and have specific needs for a solution that a blockchain fulfils.

Service tools and marketing analyses can be used to articulate the business or other needs a service fulfils, identify key stakeholder groups, and provide an engagement plan for the identified actors. Those groups could include end users, other relevant organisations, vendors, third-party developers, and so on.

Summary

This chapter enumerated 10 common misconceptions about blockchain. We list them and our specific answers to the myths in Table 2.1.

Table 2.1. Summary of top identified myths

Myth	Answer
1. (Public) blockchains are disrupting the public sector all around the world.	Blockchain-related public services that have actual users are very rare.
2. It is impossible to build successful blockchain applications for the public sector	There is no obvious reason the public sector could not develop, implement, and use blockchain solutions.
3. There is one obvious way to apply blockchain technology in the public sector.	Blockchain could bring benefits to a number of areas.
4. If you build it, users will come.	Users need to be presented with the benefits of the services.
5. If it is blockchain, it needs to be big and disruptive.	Small, pragmatic, and evolutive blockchain implementations are just as valuable.

[22] See also Myth 4. "If you build it, users will come."

[23] See additional discussion on this at https://www.invisionapp.com/inside-design/blockchain-ux.

[24] See https://slate.com/technology/2019/02/blockchain-government-regulation-cryptocurrency-bitcoin.html.

6. Nobody knows how blockchains are implemented.	Technology and corresponding skills have developed in both the public and private sectors in recent years, and there is greater access to external skills (e.g., through partnerships or procurement).
7. Blockchain is a generic technological solution, similar to AI.	Uses for blockchain technology are much more limited in their scopes.
8. We are not tech people and should not care about detailed design decisions, such as blockchain.	Decoupling design from the implementation does not seem warranted.
9. Results of blockchain projects contribute to blockchain knowledge.	Experimentation is important, but those lessons and takeaways should be shared.
10 Users care that services are based on blockchain.	All other things being equal (e.g., equitable decisions, privacy of personal information, etc.), service end users do not generally care which technological infrastructure provides them with a service.

3 Blockchain project success and non-success factors

When discussing public sector blockchain, it is useful to note that public sector actors play various roles in advancing the technology.[25] The focus here is on public sector actors considering deploying blockchain in public services.[26]

Blockchain technology can play various roles in the deployment of public services, but it is not a silver bullet. Many early examples, such as public sector initiatives related to distance voting, tokenised asset transfers, and self-sovereign identity promised dramatic and often disruptive changes to public services that, as this paper discusses, have not yet fully been realised[27]. However, blockchains might also play a smaller role in implementation, such as in the case of the Estonian KSI blockchain, which guarantees the integrity of data assets. There is also an element of expectation management involved, as a technology project's outcome might use the blockchain solution for a small part of the overall service. Determining the project's ambition level is important. More evolutive approaches might not lead to revolutionary services but are probably easier to manage as technology projects.[28] Blockchain technology could even serve as part of the core infrastructure or service stack in ways that remain invisible to a service's end users.

In the following chapters, we discuss blockchain success, which we define for this report as providing blockchain-based services that have moved to the "live" stage of their life cycles and achieved some degree of user acceptance. We also discuss factors that can lead to non-success or failure.

[25] Public sectors are organised differently in different countries, but their overall structure is often divided into levels such as international, national, regional, and local. However, where political systems vary, different actors are more powerful, and the levels might have varying autonomy. Some are more relevant for certain roles (e.g., regulation is often carried out and agencies are organised nationally). The role of political processes and party politics also varies by country. These differences have a direct impact on which level or levels are relevant in terms of blockchain implementation. This report is intended for decision makers at various levels, but we expect most readers to be at the national level. However, we do not want to downplay local blockchain pilots. Some of the most interesting public service blockchain projects have been organised by cities and local governments.

[26] In earlier OECD work (Ubaldi et al., 2019[35]), these roles were divided into regulator, financier or direct investor, convener and standard-setter, and public service provider. In the regulator role, the public authority sets a society's rules. In the financier or direct investor role, the government provides funds for research and innovation. In the convener or standard-setter role, the government facilitates efforts to provide products and services for society. In the provider role, various government actors provide public services. The public sector is also a big user of other public sector services and data, but this is outside the scope of this report.

[27] There are use cases in which blockchain implementation might pose specific risks. Such systems involve, for example, potential compromises of the legitimacy of public sector actors. Examples of risky use cases could include blockchain services related to electronic voting, electronic identification, or public sector-backed or pegged community currencies.

[28] See also Myth 5. "If it is blockchain, it needs to be big and disruptive."

We focus on the following in detail:

- Projects that have lifecycles in which they move from limited pilots and experiments into service deployment to users (deployment). We are interested in those projects that have already launched ("gone live") and obtained users.
- Projects that have moved from limited testing to acquiring actual end users (use). In other words, the project's user base is not limited to test users.
- Users who have agreed to use the service (continued use) and for whom user engagement data are being accumulated.

We divide blockchain success into two categories: success related to blockchain **projects** (Chapter 3) and success related to **organisations** (Chapter 4) driving the change. We begin with blockchain project success.

The literature shows that blockchain technology has been piloted in the public sector in many countries. For example, it has be used with public legal records, such as birth certificates, titles, court documents, and voting-related documents. Such uses are aimed at preventing adverse behaviours, such as forgeries and false disputes, as well as, in the case of financial records, double spending (Oliveira et al., 2018[10]). However, successful use cases (i.e., those with real users) remain scarce, and those that publish information about their users are even rarer.[29] Research has shown the varying potential of blockchain transformation (Rossi et al., 2019[11]), but evidence on public sector blockchain use cases remains quite limited (Du et al., 2019[12]; Ølnes, Ubacht and Janssen, 2017[13]; Rieger et al., 2019[14]). There are almost no published scientific evaluations of the proposed public sector blockchain use cases or ideas (Labazova, 2019[15]).

Thus, this field is far from mature, and more work is necessary to gather empirical data from actual projects in public sector organisations to determine how to engage with this technology. In fact, at this stage of blockchain development, careful evaluations of technical, business, and legal issues are needed for each public sector use case (Treiblmaier, 2019[16]).

Consultancy companies have built several blockchain maturity[30] and auditing tools[31] to support immediate project deployment[32]. However, there has been little academic evaluation of these efforts, as they are intended to help directly with blockchain projects.

From early efforts toward maturity

Earlier blockchain experiences can be characterised in various ways. Below, we divide public sector blockchain experiences into three broad stages.

1. There was an **early efforts stage** for public sector blockchain, which, in this report, is limited to the OECD publication Blockchains Unchained (Berryhill, Bourgery and Hanson, 2018[17]). Interested readers can find relevant information about the early pilots in that report.

[29] For listings of pilot use cases, see (Berryhill, Bourgery and Hanson, 2018[17]) and for a recent review see (Allessie et al., 2019[18]). For early use cases that have been suggested for the public sector, see also Appendix A and Appendix B.

[30] For an example of a maturity model from KPMG (2017[37]), see https://assets.kpmg/content/dam/kpmg/nl/pdf/2017/advisory/blockchain-maturity-model.pdf.

[31] For an example of an auditing list from Deloitte (2020[38]), see https://www2.deloitte.com/us/en/pages/risk/articles/internal-auditing-guide-to-blockchain.html.

[32] From non-private sector example, see for example: https://atrium.uninnovation.network/guide.

2. This report summarises the current **early maturity stage**, which encompasses the progress from the 2018 publication until now.
3. The third part is the **maturity stage**, which is still to come and involves finding consistently successful, documented cases of blockchains that have gained users, as well as cases of data being used for upstream services, if appropriate.

Early efforts

The earliest application built on blockchain (Bitcoin) has existed since 2008, but a push toward public sector blockchain implementations did not emerge to a significant degree until around 2017. For example, the Illinois Blockchain Initiative reported more than 200 public sector blockchain initiatives by 2017. These included practical pilots, various communities of practice, and partnerships. Some initiatives were driven by countries, whereas regional and local governments drove others. Early research papers focused more on providing terminology, frameworks, and agendas for future studies because empirical evidence from the projects was only starting to come in.

Based on analysis and outreach conducted in 2020 to draft this report, of the 200 projects identified by the Illinois Blockchain Initiative, it appears that few still exist,[33] and even those have likely undergone dramatic transitions over the years. Additionally, the initiative seems to be in hibernation. Tracking these projects' institutional impacts is challenging, but we would expect that those impact have been considerable.

Early maturity

This is the current stage. Researchers and practitioners are gathering evidence of successful use cases, but we are seeing promising candidates struggle to move projects into live, non-pilot stages.

The EU Joint Research Centre (Allessie et al., 2019[18]) presented an in-depth report on seven blockchain pilots that have acquired users. At the time of this writing, however, it remains unclear how successful many of the early projects have been. About half the reported cases have been suspended because they either reached their goals naturally or stopped before moving into large-scale production.

Blockchain maturity

We have not yet reached this stage, but we hope to do so within two years, or at least to have solid examples of mature implementations. In order to reaching this stage the technology must prove its worth. We have carefully documented successful use cases that explain how and why the technology has been adopted. However, it would be beneficial for these projects to demonstrate verifiable user data, and preferably downstream usage. For example, projects on credentials must demonstrate that credentials are not only issued, but also actively used for some (third-party) external service.

Project success and non-success factors

Despite several years of development, convincing pilots and proofs of concept have yet to bear fruit and scale up, by and large. This is somewhat surprising for such a talked-about technology. Some applications are utilised as small components of larger service deployments and in iterative rather than disruptive ways (see examples below).

[33] Quite a few use cases on the list return errors when contact persons are contacted, and it is relatively easy to see that many of the early actors are now working with other projects.

We have observed progress in that the technology can be deployed by public sector actors for uses such as education credentials, public procurement systems, and various electronic identity and voucher systems based at least partly on blockchain. Many cases seem to use permissioned blockchains, which is not surprising based on previous research and the characteristics of public sector use cases (Berryhill, Bourgery and Hanson, 2018[17]). However, the ultimate test for these systems will be whether private or other downstream actors use the systems and/or their outputs. Will other actors use blockchain-based educational certificate, voucher, and electronic identity systems? Will they accept the outputs of these systems?

Below, we list some of the key lessons that we have learned while conducting research, reviewing successful blockchain projects, and meeting with the teams behind these projects to discuss their efforts, results and feedback. Appendix A and Appendix B provide details on selected examples. We seek to examine early signals of success and non-success to identify key themes and characteristics behind these projects, even though some evidence might be anecdotal at this point. It should be noted that this is explorative work; the derived lists are not necessarily exhaustive and will require re-evaluation when there is a larger number of successful, well-documented public sector pilots from which to draw. Future work will also need to investigate public sector blockchain projects using statistical methods for more generalisable findings.

Key factors (see Table 3.1. Factors contributing to success and non-success in blockchain projects

below) that lead to project success include clear value proposals, appropriate technology, stakeholder management, user focus, and experimentation. Non-success factors are legal uncertainty, limited scalability, and disruptiveness.

Table 3.1. Factors contributing to success and non-success in blockchain projects

Factor	Type	Description
Clear value proposal	Success factor	The project must address a clear, specific business goal.
Appropriate technology	Success factor	The project must use appropriate technology.
Stakeholder management	Success factor	The project must identify and manage relevant stakeholders.
User focus	Success factor	The project must engage end users with the service's design.
Experimentation	Success factor	The project must address problems encountered during implementation and pursue unforeseen opportunities.
Disruptiveness	Non-success factor	Disruptive projects are generally more complex and difficult to implement.
Limited scalability	Non-success factor	The deployment of projects with limited scalability may be impossible or not worth the effort; however, they may provide learning opportunities.
Legal uncertainty	Non-success factor	Lack of clarity regarding the legal or regulative side hinders service deployment.

Source: OECD.

We discuss these factors in further detail below.

Clear value proposal (success factor)

The most critical part of setting project goals is clearly identifying the business benefit the project is expected to deliver. The consulting firm Gartner Insight (Furlonger and Valdes, 2017[19]) suggested that

90% of blockchain projects are driven by fear of failing to get on the bandwagon, do not actually need blockchain to meet their requirements, or result in solutions that are unsuitable for the current IT infrastructure.

Ølnes et al. (2017[13]) listed detailed blockchain promises for the public sector, including improved transparency, fraud avoidance, reduced corruption, increased trust, auditability, resilience, better data quality, and security. Current blockchain potentials are often linked to aims such as decreasing transaction costs, disintermediating trusted third parties, increasing transaction transparency, and mitigating processing risk using an irrevocable shared account of earlier transactions (Xu et al., 2017[20]; Lindman, Tuunainen and Rossi, 2017[8]; Iansiti and Lakhani, 2017[21]). Whatever their chosen goals, however, successful projects must articulate and deliver business benefits.

In addition to research, findings in our review of successful and non-successful blockchain projects also reveal that 'clear value proposal' is a factor that is critical to success. One such example is discussed in Box 3.1.

Box 3.1. The Stadjerspas vouchers issued in Groningen, Netherlands

The Stadjerspas vouchers issued in Groningen municipality (Netherlands) provide an interesting use case (see Appendix A for a longer description). Various identity and wallet solutions are useful for identity provision and the issuance of, for example, vouchers. Blockchain infrastructure enables digitisation of the issuance of vouchers in these use cases. After setting up their accounts, users can manage consent to access specific credentials on their mobile apps. Such services do not really require blockchain infrastructure to operate. Blockchain provides the wallet infrastructure: Users control who can access their data. In this case, the government-side efficiencies relate to digitising the process, which also increases the control issuers have over the vouchers compared to fully paper-based systems. For example, the digital process reduced forgeries (double spending) considerably. Thus, the benefits to the organisation (i.e., the value proposal) were related to efficiency and public sector fraud reduction. More discussion about this example use case can be found in Appendix A.

Appropriate technology (success factor)

The second success factor is the project's appropriateness. Specific technology benefits related to the listed blockchain deployments resulted in increased trust, auditability[34], and information security (Ølnes, Ubacht and Janssen, 2017[13]). Earlier use cases include, among others, land title registration (Hyvärinen, Risius and Friis, 2017[22]), immigration-related registrations (Rieger et al., 2019[14]), and banking fraud reduction (Parra Moyano and Ross, 2017[23]).

On a more technical level, researchers have found that blockchain can be deployed using various methods and configurations (Xu et al., 2017[20]). Therefore, the relevant design space and design trade-offs are not trivial.[35] Figure 2.2 also listed a number of overall suitability criteria, used by the U.S. Department of Homeland Security, for blockchain evaluation, such as the need for shared consistent data storage, whether more than one entity contributes to data, immutability, lack of sensitive data, issues related to changes in data storage control, and tamper-proof logging. The relative importance of these different

[34] See JusticeChain as one potential use case for auditability from an example from Portugal. https://www.gsd.inesc-id.pt/~mpc/pubs/Paper_JusticeChain_CoopIS_2019.pdf.

[35] See also Chapter 1.2 for discussions about how vital it is to use blockchain technology for a specific purpose.

criteria depends on the specifics of the use case and the project, but overall, the appropriateness of the technology is a critical success factor for a project. One example is discussed below in Box 3.2.

Box 3.2. BlockCerts, Malta

Academic certification is a novel service that can be provided when digitalising certificate issuance to a blockchain, if the credential issuer agrees. This example combines blockchain wallet infrastructure with consent management to provide third parties with access to the certificate stored in the user's wallet. From the perspective of the university issuing the credential, implementing this use case is relatively straightforward, but the system's real test lies in generating and capturing value via third-party services. For this service, blockchain technology is particularly suited to offering a number of benefits for the user (increasing control) and the academic institution (moving away from siloed data architecture, reducing credential fraud). More discussion about this use case can be found in Appendix A.

Stakeholder management (success factor)

Identifying and engaging relevant stakeholders is important for any development project, but especially so for a blockchain project due to its technical novelty and the frequent need to on-board whole networks of stakeholders.[36] Usually, there is a public sector customer and one or more blockchain start-ups or other companies that provide the technology. Research on technical and business blockchain consortia is still emerging, but while consortia are traditional ways to cooperate in development efforts, there is a clear trend toward more collaboration in efforts related to blockchain (for a recent overview of the field, see (Zavolokina et al., 2020[24])). However, there is also a lot of variance in terms of how local the consortia are and how large they are, not to mention differences in governance models and business goals.

Among the most important actors in the network is the technology vendor, which often provides the external expertise for blockchain deployment. In public settings, this means managing blockchain technology through a public procurement process. There is growing research interest in how blockchain technology may present novel options for more decentralised governance (Beck, Müller-Bloch and King, 2018[25]) and related generative user contributions (Andersen and Bogusz, 2019[26]). Based on the reviews of the emerging literature and our empirical work reviewing blockchain projects and project team interviews, managing stakeholders is a critical success factor. Below, in Box 3.3 is an example of one interesting collaboration.

Box 3.3. The Swedish employment agency, Sweden

The Swedish employment agency works with the global insurance agency Axa (see Appendix A for a longer description). As part of this cooperation, the employment agency issues credentials to registered job seekers, who then manage consent regarding who receives access to the credentials downstream. Axa manages most of the relevant technology stack, but the employment agency provides the main ingredient: the data point of the job seeker's status. The critical point is the close collaboration of a public sector actor with a provider in terms of acquiring the needed technical tools, APIs and external expertise as well as the analytics data on system use. In this case the maintenance of the blockchain is more on the provider side, but for some other services this could also be shared among trusted actors.

[36] For example, a consortium of actors drives all cases in Appendix A.

In order to extend the service to other possible uses that depend on these credentials, it is important that a) the user can consent to provide their verified status to more third-parties, b) third parties have technical capability to get this status (from blockchain) and provide further services based on this.

More discussion about this use case can be found in Appendix A.

User focus (success factor)

Most current software approaches highlight the importance of customers and users as active participants in the design and development process. Many early blockchain projects began as technology processes aimed at implementing a specific idea for a service. However, putting the customer in control and acquiring end-user input are considered important for service design.

When the technology has matured, blockchain services should not be primarily seen as technology-driven projects, and therefore user focus is a critical success factor according to our interviews and analyses.[37] Box 3.4 below shows one empirical example of how customers are involved with the project and participate in the production of the service.

Box 3.4. The Estonian Information Systems Authority (RIA), Estonia

The Estonian Information Systems Authority (RIA) relies on the Estonian company Guardtime to provide integrity services for government data (see Appendix A for a longer description). In this partnership, Guardtime provides various technologies, tools, and SDKs for the public sector and hosts the hash-storing blockchain that can be witnessed by the participants. Public sector user organisations have a variety of options on how to engage iteratively with blockchain-backed services: some agencies choose to run their entire networks on their own for various reasons, such as security concerns. In such cases, the public sector actors are responsible for the architecture and decide how much blockchain to implement. In other words, they determine whether the entire integration service is blockchain based or uses blockchain as a complement. Customers and users are involved in the systems' use, configuration and development. More discussion about this use case can be found in Appendix A.

Experimentation (success factor)

Earlier studies highlighted the need for blockchain experimentation (see, for example, (Du et al., 2019[12]), for a recent literature review that outlines this area).[38] The purpose of this experimentation is to build in some flexibility and variation for a specific innovation process so that various attributes of the technology (affordances) can be actualised to learn about their potential outcomes.

This means testing various potential concepts during the project and learning about their constraints. This can also be done in a blockchain-agnostic way. It might not be necessary to decide before the project that the implementation must incorporate blockchain. Instead, blockchain can be one of the potential technologies the project investigates.

[37] See also Chapter 2.

[38] Although the particular article focuses on fintech, we believe the experimentation processes is similar to those of other types of organisations.

Our empirical work has examined how different kinds of development units gather internal capabilities from different parts of the internal organisation, as well as external expertise from consultants, and how projects share these experiences. Experimentation with the technology plays an important role when these blockchain development projects are formalised, for example, as submissions to hackathons, demo days, or trade shows, or when related public procurement is prepared, planned, and carried out. Based on these data and earlier research, we name experimentation as a critical success factor. Box 3.5 shows one example of experimentation.

Box 3.5. Groningen municipality, Netherlands

Over the years, the Dutch municipality of Groningen has tried out a number of different blockchain projects (see Appendix A for full list), and some have been more successful than others. The overall project organisation was different for each of the projects - probably due in part to the fact that expertise of the technology is scattered in the organisation. One important event is a well-known annual hackathon featuring blockchain where submissions were accepted from the local public sector. This event provided support in showcasing, screening and filtering blockchain-related public sector service experiments. The fact that Groningen has an active start-up scene enabled it to source local talent to blockchain-related services.

For a number of years, Groningen has worked closely and iteratively with a small local start-up as its technology provider for a specific blockchain project (see Appendix A for a longer description). The start-up used several infrastructures to deliver the service, only some of which were based on blockchain. Groningen's public procurement process was done in a blockchain-agnostic way, and the new bid winner opted not to use blockchain technology when implementing the service. More discussion about this example use case can be found in Appendix A.

Disruptiveness of the service (non-success factor)

The more the development project has the potential to disrupt current public services or affect existing markets, the more complex it will be to implement. Our review of the field revealed hundreds of inactive projects that were previously self-marketed and/or reported in other publications, but of course, many were small-scale proofs of concept or pilots that were aimed at testing the technology and learning. There was no lack of project ambition. It is not surprising, however, to see so many inactive projects.[39] What is a bit more surprising is that successes in this space seemed relatively rare.

Based on our review of the field and literature, we conclude that disruptiveness of the service is a critical non-success factor, with smaller iterative efforts appearing to have higher rates of success. We have picked one example of a project that was stopped, presented below in Box 3.6.

Box 3.6. The Tel Aviv-Yafo digital currency pilot, Israel

The Tel Aviv-Yafo digital currency pilot is the most disruptive of the examples selected for this report. Although the empirical and theoretical benefits of a digital cryptocurrency run by local authorities seem

[39] It would be interesting to review in more detail a selection of inactive cases to learn their outcomes, but this kind of large-scale data collection effort falls outside the scope of this study.

quite promising and echo what many proponents proclaim could be a great deal of unrealised potential, the pilot project suffered from a number of obstacles. The main issue is that the company has to deal with issuing the currency that is tradeable to other cryptocurrencies and/or fiat money, which requires taking the risks and designing processes that are normally required only of financial institutions (depending on particular legislation). Even if the outsourcing cryptocurrency partner company is able to fulfil the compliance requirements for private money, the municipality takes on some of the public exposure in accepting the coins and promoting them. For this to happen, the technical implementation of the currency must be mature and regulation requirements be met. More discussion about this use case can be found in Appendix A.

Limited scalability (non-success factor)

As indicated in Chapter 2, many early blockchain projects were small-scale pilots intended to facilitate learning more about the technology and potentially scale up. Some design decisions made during early phases did not scale well, such as the number of nodes or load in the network or the number of transactions. Such projects can fulfil their purposes in terms of learning and experimentation, but they will not necessarily attract users.

Based on our review of the cases and research (see, for example, (Xu et al., 2017[20])), we conclude that limited scalability is a critical non-success factor.

Box 3.7. The Lantmäteriet land registry, Sweden

The Lantmäteriet land registry (Sweden) is an early example of a relatively disruptive public service change (see Appendix A for a longer description). Many of this novel system's benefits and efficiencies were realised by digitising an analogue process. In particular, this increased transaction speed likely led directly to cost savings. Blockchain's benefits included the fact that the actors running the network could share the cost of running the service as a consortium blockchain. Blockchain infrastructure allowed for increased transparency of the workflow, which increased technical trust for the transactions on the chain. However, the disruptive nature of the new service was likely one of the reasons the project encountered obstacles and scaling difficulties. More discussion about this use case can be found in Appendix A.

Legal uncertainty (non-success factor)

In what is sometimes referred to as a "reality feed," there are legal entry points when a blockchain and the physical world intersect (for a more thorough discussion, see, e.g., (Rodrigues, 2019[27]; Werbach, 2018[28]). This is a potential risk if the project addresses a service wrought with legal uncertainty or encountering ongoing regulatory developments.

Specific challenges of the blockchain technology in many legislations are related to two characteristics: the decentralised (peer-to-peer) nature of the blockchain networks and the immutability of the stored data. In permissioned systems the additional legal safeguards can be put into place when nodes are admitted to participate in the network. For permissionless networks, the issue of data controller is more difficult to resolve and requires a more thorough investigation into architecture and data storage. Specifically, several potential legal hurdles are posed by personally-identifiable information stored into an immutable blockchain. The easiest way to allay this concern is not to store this information in the immutable ledger. For a much more thorough and nuanced discussion around these two legal themes see for example Panel

for the Future of Science and Technology (2019[29]). Although this example focuses on GDPR, many governments not subject to GDPR are working through similar issues. Another area of emerging legislation has to do with smart contracts.[40] To provide a safe environment for experimenting with blockchain without fear of legal repercussions, some governments have worked to develop legal and/or regulatory sandboxes,[41] which can help separate data while governments and their partners learn more about blockchain potential and sensitivities.

We conclude that legal uncertainty is one of the critical non-success factors. Below in Box 3.8 is one example of a service that had to overcome a number of issues related to legal uncertainty.

Box 3.8. The Lantmäteriet land registry, Sweden

The Lantmäteriet land registry (Sweden), as touched on in Box 3.7, pioneered a number of developments and novel technologies when digitalizing its transaction system. For example, the project had to address questions related to mandatory paper copies, identification (e.g., via mobile number subscription), and non-digital signatures. In addition, GDPR-related requirements were introduced in the middle of the project. Although it is sometimes difficult to foresee potential changes in legislation, shifting or volatile legal environments can pose challenges for projects. More discussion about this use case can be found in Appendix A.

[40] There is a separate report from the OECD that tackles some of these issues. OECD. (Forthcoming). “Future of Regulation: case studies on the regulatory challenges raised by emerging technologies and the regulatory responses”.

[41] An example of a legal sandbox would be OPSI https://oecd-opsi.org/innovations/lbchain-blockchain-sandbox/

4 Organisational and team success: measuring digital maturity

A growing number of public and private sector organisations are being mediated by and organised around digital technologies to maintain high levels of competitiveness and improve the experience for those using their offered products and services. As citizen expectations change, private and public sector service providers must keep pace. If people lose trust in traditional public institutions, digital technologies and data give governments an opportunity to transform internal processes, policies and services, and respond to the real needs of the governed.

Blockchain-based solutions potentially offer benefits such as transparency, accountability, security and efficiency and are therefore an attractive proposition for the public sector. However, as discussed in Chapter 1, there are important considerations to bear in mind about whether the use of blockchain, or any other technology, is viable, valuable or vital in meeting a particular set of needs and/or solving a specific problem. The digital government maturity of a country shapes the context for decision making on the suitability of blockchain to improve public sector policies, processes and services.

But what are the building blocks that help governments develop the maturity to make good decisions about the use of a given technology? And, having taken such decisions, how can the maturity of an organisation influence the success, or otherwise, of blockchain enabled delivery? This chapter approaches these questions by, first, introducing the OECD's work on measuring the maturity of digital government using the Digital Government Policy Framework (DGPF) (OECD, 2020[30]). The second part of the chapter then takes the DGPF framework and applies it to a discussion of 1) organisational maturity in taking suitable decisions around technology and 2) team maturity in implementing blockchain-based projects in the public sector. Although the observations of maturity are focused on blockchain, this framework could be applied to any digital technology with the potential to disrupt policy and service design and delivery in the public sector.

Understanding and measuring digital maturity in the public sector

Since 2014, the OECD Recommendation of the Council on Digital Government Strategies (OECD, 2014[31]) has been the basis for promoting the transition towards mature digital governments. The Recommendation provides 12 strategic priorities for governments to move from e-government[42] to digital government[43]. The actions it sets out advocate for a cultural change within the public sector, drawing upon the strategic use

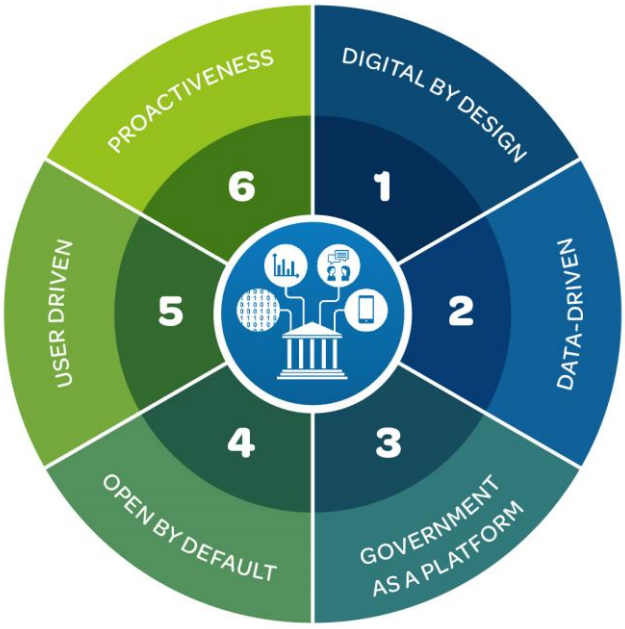
[42] According to the Recommendation, *E-Government* refers to the use by the governments of information and communication technologies (ICTs), and particularly the Internet, as a tool to achieve better government (OECD, 2014[31]).

[43] According to the Recommendation, *Digital Government* refers to the use of digital technologies, as an integrated part of governments' modernisation strategies, to create public value. It relies on a digital government ecosystem comprised of government actors, non-governmental organisations, businesses, citizens' associations and individuals, which supports the production of and access to data, services and content through interactions with the government (OECD, 2014[61]).

of digital technology and data to better support public sector operations and shape government strategies, decisions and policies for public sector reform and modernisation.

Assessing the suitability for broader adoption and implementation of an emerging technology such as blockchain and then creating an environment in which it can be successfully implemented is indicative of a mature approach to digital government. To help decision-makers, practitioners and digital enthusiasts understand and measure such maturity the OECD Secretariat has developed the DGPF (OECD, 2020[30]) (Figure 4.1).

Figure 4.1. The Digital Government Policy Framework (DGPF)



Source: OECD (2020[30]).

The six dimensions of the DGPF highlight different strengths and weaknesses in the digital maturity of a country and its public sector organisations. The following four dimensions, referred to as ***Foundational***, are the building blocks for effective digital government reforms. This first set of dimensions provide the basis for digital government, enabling teams and policymakers to strategically embed digital and data at the core of government processes and services, with the ultimate goal being to create public value.

- A government is **Digital by design** when digital technologies are used to:
  - rethink, reengineer and simplify public processes and procedures
  - integrate public sector organisations to deliver coherent, timely and omni-channel service delivery
  - create new channels of communication and engagement with public stakeholders for a more efficient, sustainable and citizen-driven public sector
- A public sector is **Data-driven** when it:
  - generates public value through the reuse of data in planning, delivering and monitoring public policies and services

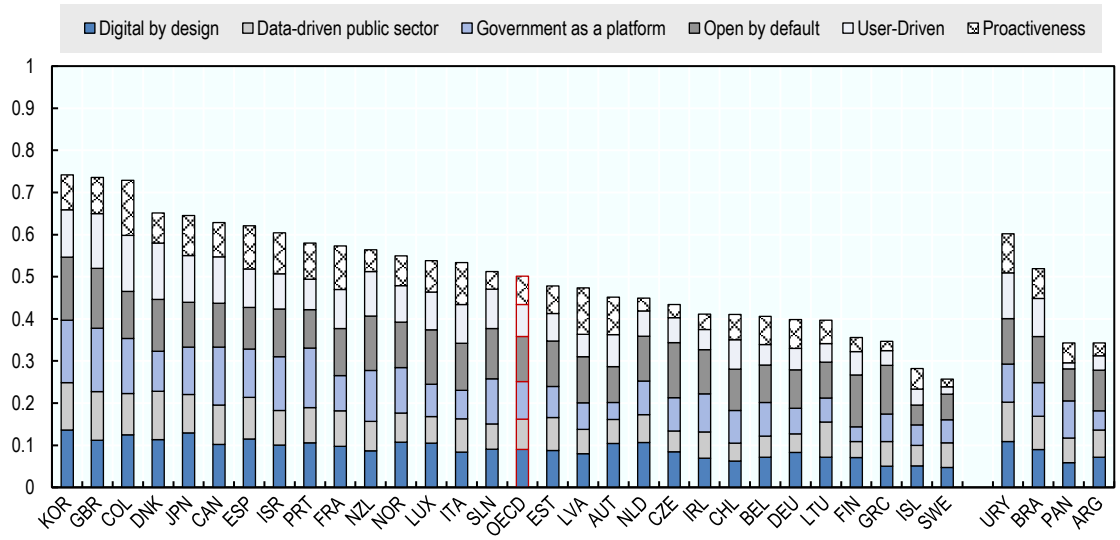
  - ensures that data are used and shared in a trustworthy fashion, and under clear protection, privacy, and security rules and according to ethical principles for national and public interest
- A **Government** acts **as a platform** when it:
  - provides clear and transparent guidelines, tools, data and software that equip teams to deliver user-driven, consistent, integrated and cross-sectoral services
  - deploys a wide range of platforms, standards and services helping teams focus on user needs in public service design and delivery
- A government is **Open by default** when it:
  - makes it possible for the public to engage with the policy design, design-making processes or access government data within the scope of applicable laws and in accordance with public interest
  - opens data, information, systems and processes to build bridges between all actors, collecting insights towards a more knowledge-based public sector

Building on these foundations are a further pair of ***Transformational*** dimensions. They represent the highest level of maturity, demonstrating efforts of public sector organisations to utilise digital technologies and data in order to focus on, understand and respond to users' needs proactively and seamlessly.

- A government becomes more **User-driven** by:
  - placing the needs of people at the heart of shaping policies, services and processes
  - establishing collaborative mechanisms and policy processes to shape outputs and outcomes that reflect an understanding of the decisions, preferences and needs of citizens
- **Proactiveness** represents the ability of governments and civil servants to:
  - anticipate people's needs and rapidly respond to them
  - offer a seamless and convenient service delivery experience to citizens
  - address problems from an end-to-end rather than taking a fragmented approach

The DGPF not only aims to characterise the elements required to drive the digital transformation in the public sector, but also to serve as basis to measure the transition from e-government to digital governments. With this purpose in mind, the OECD developed the 2019 Digital Government Index (DGI), a first effort to benchmark the maturity of digital government reforms in Member and partner countries based on the six dimensions of the Framework (OECD, 2020[32]) (Figure 4.1).

Figure 4.2. The 2019 OECD Digital Government Index Composite Results



Note: Data are not available for Australia, Hungary, Mexico, Poland, Slovakia, Switzerland, Turkey and the United States.
Source: OECD (2020[32]).

The results of the OECD's Digital Government Index for 2019 suggest that governments could make more strategic use of digital technologies and data across public sector organisations. With a limited yet promising transition to digital governments, leading countries have laid down a foundation for digital to thrive in the public sector. Indeed, they have assembled the building blocks necessary to adopt digital technologies and data that solve specific problems and meet user needs. Cross-government strategies, dedicated decision-making and coordination bodies, suitable regulation and guidelines, skills and funding initiatives are some of the elements leading governments in the DGI have developed for sound implementation of digital government projects, and which can inform public sector organisations with the critical elements needed for the use of blockchain in the public sector. As countries advance on their levels of digital maturity, they will be able to fully exploit the potential benefits in the use of data and emerging technologies for more transparent and accountable processes and services.

Assessing suitability and implementation of blockchain under the Digital Government Policy Framework

The DGPF defines the foundational and transformational capacities for a digital government maturity that enables agile, responsive and resilient governments. As governments change the underlying culture of their public sectors, digital technologies and data become an integral part of modernisation strategies to create public value in every sector and organisation. The DGPF provides the framing for this by highlighting the importance of taking cross-government approaches that break down siloes and solve whole, end-to-end problems for citizens and public servants. In the case of blockchain, its use should therefore follow from such a strategic approach and not on a project-by-project or case-by-case basis.

One of the most important areas of this culture change is the way in which organisations make decisions about the role of technology, approaching the problem to solve and needs to meet instead of the solution to implement. A second critical consideration is the way that digital maturity informs the environment in which teams operate. Having introduced the conceptual framework and presented the measurement tool, this chapter will now apply the DGPF to these twin questions of maturity in relation to blockchain-based

projects. Firstly, by considering the elements of digital government maturity that support organisations in their decision making about blockchain. Secondly, by considering the maturity of the environment in which teams operate and the support they require to effectively work with, and understand the suitability of, blockchain.

The maturity of organisational decision making about blockchain

Digital government maturity at an organisational level embeds a cultural and practical approach to meeting the needs of the public that maximises the potential for digital technologies and data as part of broader, strategic efforts. This next section will consider the indicators of that maturity in the context of emerging technologies where the foundational elements of digital by design, data-driven, government as a platform and open by default, make space for experimentation and innovation while also developing the necessary skills to make informed and strategic decisions that remain focused on maximising public value to fulfil the transformational vision for a user-driven and proactive government.

Digital by design

A government that is digital by design establishes clear leadership paired with effective coordination and enforcement mechanisms (OECD, 2020[30]). At the organisational level, having a public sector organisation responsible for leading and coordinating decisions on digital government with advisory and decision-making responsibilities helps to improve the development, monitoring and coordination of all digital projects, including those that investigate the use of emerging technologies such as blockchain. These organisations enable prioritisation, approval, revision and monitoring of digital technology and data projects across the government.

Together with clear leadership, strong political support that embraces innovation is another enabling condition for strategic applications of emerging technology in the public sector. Political support encompasses a pro-active engagement of governments and top-officials towards the adoption of the necessary infrastructure to support innovation with technology (Ubaldi et al., 2019[33]). The public sector also needs to create a culture where innovation and modernisation are a priority. Suitable knowledge and skills must be developed to create a pool of experts that will then assess the relevance, impact and added value of a certain technology. Continuous education, training and skills development programmes should be provided to secure institutional buy-in and facilitate short- and long-term transitions as public servants migrate from one job to another (Ubaldi et al., 2019[33]).

Digital by design thinking encourages the development of far-sighted, comprehensive and ambitious National Digital Government Strategies (NDGS) that incorporate a strategic perspective on the role of emerging technologies in the public sector. The NDGS can provide the basis for a country's vision for emerging technologies in transforming governments' operations and service delivery. It is essential that a country's NDGS be accompanied by practical actions for relevant actors to achieve goals and ensure the support of plans, guidelines and standards. This can then foster a common approach in the assessment, implementation and adoption of technology.

An important lever for governments to help oversee these standards, secure coordination in delivery and incentivise particular strategic goals is the design of business case methodologies and related financial management for digital projects. Business cases can be an important tool to assess the cost-benefit and value proposition of technologies, including blockchain. Identifying alternatives, assessing their qualities and resources needed for implementation are critical aspects when evaluating the pertinence and added value of a certain technology. Access to funding that allows for experimentation and exploration of solutions to needs that deploy emerging technologies is important to allow freedom to develop new ideas and practices. Nevertheless, this should be reinforced with a strong evidence-based approach to monitoring the efficiency of public investment for the development and adoption of technologies to account for return

on investment and to either release further funding to encourage innovative approaches to become mainstream, or identify failing projects and intervene as necessary.

Data-driven public sector

Maturity of data-driven government reflects an ability to strategically unlock the value of data. Because blockchain-based solutions are often identified in the context of handling data, this aspect of organisational maturity is critical to effective decision making about their use or value. This requires an approach to data governance that addresses strategic, tactical and operational considerations (OECD, 2019[34]).

The primary aspect is implementing a public sector data strategy that sets a common view for data collection, management, sharing and use with the aim of improving service delivery, better informing decision-making enhancing operations and fostering trust through privacy, transparency and accountability.

Besides adopting a strategic approach, institutional arrangements are important to embed a data-driven culture within the public sector. While this may manifest itself in the leadership roles for public sector data initiatives and policies (e.g. Chief Data Officers), which could aim, for example, to improve coordination in implementing the public sector data policy, it also requires securing the necessary data capabilities to support implementation. These capabilities could include regulation or skills that are particularly important in creating the right environment for decision making about the potential for blockchain-based solutions.

Mature data-driven governments build trust in their use of data through developing formal requirements, guidelines and enforcement mechanisms that support transparency, consent, openness and security of data. In the case of blockchain and its appropriateness, these concerns are important with several areas bringing the relevance of the technology under consideration. For example, although distributed ledgers are argued to enhance protections around consent, privacy and confidentiality there are valid questions concerning the implications for citizens of an immutable technology from which information can never be removed.

Government as a platform

Maturity of the government as a platform approach at institutional level is demonstrated through developing clear, accessible and common resources and tools such as guidelines, common components, data and applications that enable public sector organisations to benefit from interoperability of delivery in terms of both technology and practice. As a result, service design and delivery is opened up to greater innovation both inside and outside government (OECD, 2020[30]). Organisations that provide resources, whether locally or on behalf of the whole-of-government can ease access, facilitate understanding and increase coherence of digital and data solutions regardless of the technology that is deployed.

In the case of blockchain, there is an important enabling function for organisations to provide resources discussing how and whether to deploy blockchain in line with the discussions earlier in this paper about value, viability and vitality. Acting from the centre to communicate best practice and guidance over the right approaches to take in considering blockchain-based activity in efforts to meet the needs of users is a critical contribution to helping to make the right decision.

More broadly, the investment in the infrastructure to support a strategic approach to the use of blockchain in a given country should focus on enabling those appropriate use cases, and not become a route to automatically assuming blockchain is the most appropriate tool for a given situation. The strategic development of national infrastructure can be particularly valuable in avoiding the duplication of effort and ensuring consistency of approaches whether in supporting the use of blockchain in the public sector or other common challenges.

Furthermore, some of the most interesting government as a platform interventions like EBSI (Box 1.2) are coming from a recognition that the decentralised nature of blockchain solutions may make them suitable for cross-border activity between governments where tools and resources can help to scale not only national efforts but solve international challenges too.

Open by Default

An *open by default* organisation seeks to promote openness of processes, systems, information and data, unless there is a compelling reason not to (OECD, 2020[30]). Maturity in the context of blockchain means *looking externally to strengthen interactions between governmental and non-governmental actors* (experts, citizens, business, academia) to identify priorities, seek input, share best practices, implement, monitor and understand the implications of the technology. This is complemented by efforts to incorporate, either as a legal requirement or as a recommendation, consultations as part of the process for designing policies or services.

The necessary tools to encourage collaboration internally within the public sector as well as externally is an important element in establishing an *open by default* culture. Equally important is *investment in the infrastructure to enable departments to release their data, share processes and put in place the necessary guidance to operationalise openness*. In this environment, the purported benefits of transparency and decentralisation associated with blockchain may prove attractive in deciding whether it is suitable.

User-driven and Proactiveness

Proactiveness and user-driven build upon the abovementioned foundational dimensions and represent the more delivery-focused efforts of public sector organisations to utilise digital technologies and data in order to meet people's needs (OECD, 2020[30]). Governments are user-driven when they establish new forms of partnerships or crowdsource ideas to achieve legitimacy and trust. Combined with proactiveness, governments achieve the highest levels of digital maturity when they manage to offer a seamless and convenient service delivery experience to citizens, shaped around their needs, preferences, circumstances and location. This requires governments to be equipped to anticipate and address problems from end-to-end rather than through a fragmented and reactive approach.

Blockchain is a technology with the potential to create more seamless government services and unlock proactiveness in the delivery of government services. Understanding how to deliver on these possibilities and the benefits it may offer could enhance trust in blockchain, and decisions around its usage should be guided by a user-driven and cost-benefit approach. This includes not only considering the development of the technology itself but also, at an organisational level, developing mechanisms to ensure effective accessibility, inclusion and active engagement on processes, policies and services with greater focus on people's needs. For this purpose, mature organisations establish dedicated mechanisms to systematically capture, study and understand the needs of users and use outputs to inform decision-making processes.

The maturity of the environment in which teams work with blockchain

The different aspects of the DGPF discussed in the previous section inform how effectively organisations might consider the potential use of blockchain within an overall strategic approach to digital government. This section looks at a second area of maturity that concerns the environment within which teams attempt to deliver digital government activity, and how they approach projects where the use of blockchain could be considered.

Digital by design

Leadership is intrinsic in encouraging digital transformation in the public sector. Combined with a "culture of experimentation", it creates space for designing, testing and improving products as part of an iterative

process where failure is not to be feared. This ensures teams are empowered to respond to the needs of their users with the most suitable approach, not with any pre-determined choices around technology. The alternative, a culture that pursues blockchain 'pet projects', without first considering users' needs, relevance, appropriateness and efficiency gains, entails risks in the cost-effectiveness or success of a given project.

Successful teams draw on a range of multi-disciplinary skills and technical capabilities to rethink and re-engineer services, and simplify procedures for a more efficient and sustainable public sector with access to a sophisticated understanding of technology whether that is tried and tested or more experimental and emerging as in the case of blockchain. A lack of sufficient blockchain skills can have serious implications for the success, or otherwise, of blockchain-based efforts.

Ongoing funding is critical for teams to develop their ability to meet the needs of their users, especially when projects are challenging. Financial resources back a culture of experimentation, leaving room for failing, testing and improving products as part of an iterative process. Uncertainty about ongoing funding could render projects unsustainable, jeopardising promising long-term outcomes. Ongoing funding should be combined with sound cost-benefit analysis (e.g. business cases) to critically assess the added value of a specific technology and the investments needed to deliver public value. Furthermore, a strong analytical basis that benchmarks performance metrics and develops the means of evaluating the success of ongoing projects at an early stage can allow teams to assess whether the blockchain solutions that have been developed do indeed continue to serve the identified need and add value, or should otherwise be abandoned.

Data-driven public sector

A data-driven public sector recognises the important role of data in generating public value through the reuse of data in planning, delivering and monitoring public policies (OECD, 2020[32]). Embracing the data-driven public sector is a critical element in the successful delivery of public services. The nature of blockchain and its architecture means the quality and availability of data within a given context can have a significant influence on the development and implementation of projects. At a team level, being able to access data and benefit from an interoperable architecture between other teams or public sector organisations is likely to be an important part of delivering successful end-to-end services. In the case of projects that chose to use blockchain as the basis for handling data then the nature of this broader ecosystem can prove significant in determining the success, or lack thereof, of the overall ambitions.

The skills and capabilities to work with data within the team are therefore important not only for data gathering, sharing and discoverability but also for identifying sources, quality and relevance of data. Training is valuable to ensure public servants recognise and deliver against common standards, understand their legal and ethical obligations and consider the full data lifecycle in their work (OECD, 2019[34]).

Government as a platform

The experience of Government as a platform within teams draws on the upfront infrastructure created by governments to support the delivery of public services quickly and on a sufficient scale. Recognising that the diverse challenges raised by digital government transformation requires a holistic, whole of government approach, teams should be able to benefit from a broad range of platforms, standards and services to help them focus on user needs in public service design and delivery, rather than on technological solutions.

At a micro level, this means that teams are able to concentrate on understanding the needs of their users and responding to them rather than the overhead of developing solutions that could otherwise be provided once and then deployed across many projects. In the case of blockchain, it is possible to provide underlying architecture and resources through central infrastructure in order to support teams with more coherent and

effective implementation. In the EU, the EBSI project provides not only the technical underpinning through its APIs and Sample Applications but also services including community management, connectivity testing, a knowledge base, a service desk and a training service.

Other important elements that can support teams in benefitting from a Government as a Platform that encourages the adoption of blockchain-based solutions is a broader set of infrastructure, particularly concerning data. Although questions of data governance and utility are discussed earlier under the Data-driven public sector, at an operational level, questions of common standards for data availability, interoperability and single data inventories can facilitate the work of teams exploring the use of distributed ledgers. Given the scope and complexity of the public sector, there is a risk that the lack of data and interoperability of systems could lead to transformation of governments in piecemeal fashion, with solutions siloed by department and duplication of data, technology, and process rather than delivering in a timely manner at the scale, coherence and effectiveness required.

Open by Default

Considering the role of open by default in creating a collaborative and knowledge-based public sector (OECD, 2020[30]), teams can benefit from an open by default culture when they are incentivised to promote collaboration and innovation. Teams are also more likely to succeed when the have the tools and practices needed to open up and co-design government processes. The purported benefits of blockchain – accessibility, transparency and trusted information – are integral aspects of an open by default mindset and should form part of the culture of teams. Being committed to developing a community of blockchain expertise with which public servants engage to share best practices and learn from experience are concrete examples of what an open by default approach can offer to enable blockchain projects.

Encouraging the creation of the necessary tools such as infrastructure for releasing departmental data and information are also important mechanisms that allow collaboration and which teams can rely on for developing blockchain solutions. Conversely, a lack of openness hampers access to information, favours projects being designed to the limits of teams' boundaries and nourishes a "work in silos" approach. This reduces the likelihood of success and may well lead to inefficiencies with major limitations on the effectiveness of delivery.

User-driven and Proactiveness

Teams adopting a user-driven approach to their delivery is one of the most important ambitions of digital government activity. High levels of maturity in this respect will see governments entrust citizens with a central role in contributing to the design of policies and services. The most significant implication of this in terms of blockchain is that a user-driven team will be equipped and committed to meeting the needs of their users rather than the technology itself. Designing and delivering without taking users into account risks adopting meaningless solutions that ultimately fail to resolve the need.

Relying on organisations to create the right environment to deliver on the needs of users means that teams should be able to draw on advice and materials supporting the accessibility of digital government services following an omni-channel model to reflect the preferences and needs of users. This is particularly important to avoid the delivery of solutions that neglect part of the population, which further increases the digital divide.

Organising public consultations, workshops, user research and testing sessions are some examples of concrete actions teams can take to engage end users in service design and help secure legitimacy and pertinence of technology in solving a specific need. These considerations will ensure that the overall solution and service being developed is well-designed and flesh out any considerations that are needed in terms of communicating the role of blockchain or its functionality if it forms part of the solution.

A valuable part of the ecosystem supporting the design and delivery of public services are those aspects which support innovation and experimentation. Government support of regulatory sandboxes, innovation centres and policy labs can provide environments in which blockchain architecture and solutions can be tested with a view to proactively exploring the transformation of particular services. This openness will help meet user needs and test the feasibility of blockchain. Such approaches ensure rapid and agile policy responsiveness whereby experiments are deployed, evaluated, modified or abandoned quickly.

This paper highlights that at the moment blockchain does not form the basis for a wide and extensive selection of concrete projects with significant levels of usage. Although there has been a lot of discussion about pilots and potential projects there is limited access to information about successful implementations – it would therefore be valuable for successful blockchain projects to proactively engage users and other stakeholders to provide helpful insights.

Concluding reflections on organisational and team success and maturity

As can be seen in this working paper, there are situations where the use of blockchain can be viable, valuable and vital for public sector services and processes. Where that is the case, organisational and team maturity is an important factor contributing to success when it comes to establishing the suitability of blockchain and its subsequent implementation. The Dutch municipality of Groningen, one of the examples discussed in the paper, has taken their experience with blockchain and developed a localised approach to measuring maturity (see Box 4.1). They identified six metrics measuring user need, capabilities, strategic technical architecture, legislation, data and transformation, which are useful at a project level and can be used in a workshop setting to ensure that any team committed to blockchain covers the different issues that might arise.

Box 4.1. Measuring organisational blockchain maturity in Groningen, Netherlands

Groningen municipality (Netherlands) tested this described checklist in a workshop setting (see Appendix A for a longer description). The workshop invited key stakeholders and organisations' blockchain experts to discuss how blockchain-related activities were organised in the municipality. Participants worked together to identify and to assess the blockchain-related capabilities of their organisations. Participants were asked to grade their organisations on the different identified scales. This information was used as a benchmark for further potential workshops with the municipality or other municipalities for a relatively mature public sector blockchain organisation.

Below, the six derived questions related to blockchain maturity form a checklist that can support organisational development related to blockchain.

"As an organization, we have ...

1. Identified/captured a need that can be effectively solved using a blockchain application.
2. A clear understanding of the roles required in our application and the people who should fill those roles.
3. A well thought-out strategy for making design choices regarding the blockchain architecture.
4. Identified with which legislative areas we must comply.
5. A clear understanding of the kinds of data we should store on and off the blockchain.

6. Discussed if or how blockchain-based government services can change the roles, needs, and mandates of the public sector.

Several potential issues were identified, for example scattering the expertise in different parts of the organisation, modifying the organisational structure that resulted in changes, and needing to gather information about the different organisational initiatives carried out in the blockchain space. Several learning opportunities related to the existing projects were also identified: for example, those related to specification documents and participation in a local hackathon and blockchain-related public procurement processes in the municipality.

However, this paper looks to a broader maturity around the use of blockchain that is primarily based on the idea of organisations identifying and understanding user needs and then—and only then—considering specific technology as an enabler for meeting that need, instead of vice versa. Thus, the starting point is not a specific technology (blockchain). Instead, the choice of technologies follows as part of an iterative approach to testing and learning how to respond to a specific user need.

This must take place within the organisational context of coherent and aligned development of digital government reforms to support whole-of-government rather than silo-based approaches to assessing, implementing and adopting digital technologies and data, including blockchain. In this sense, the public sector would benefit by addressing emerging technologies under the leadership, vision and strategic approach of the leading digital government organisation that promotes a culture of critical assessment, peer-learning and collaboration in strategising with such technology.

This starting point also shifts the focus from a specific technology to the overall capabilities and processes of public sector organisations. Understood in this way, maturity is about ensuring access to the right skills and capabilities to deliver against that original user need. Strategic choices in terms of design tie back to meeting the need, where a multi-disciplinary development team considers the user need against a specific technology landscape and works toward adding value to a specific service.

The different elements of the DGPF, namely digital by design, data-driven public sector, government as a platform, open by default, user-driven and proactiveness, provide a comprehensive frame for considering maturity in the pursuit of digital government. The measurement tool DGI, which uses the framework as a basis, has benchmarked and evidenced the need of countries to advance on their levels of digital maturity to fully exploit the potential benefits in the use of data and emerging technologies for more transparent and accountable processes and services. This chapter has summarised the different organisational, and team level, activities that are needed to support that effort in the application of blockchain.

5 Conclusion and recommendations

When considering a blockchain innovation project, a public sector official should have:

1. Identified needs that can—*only*—be addressed using blockchain technology (Chapter 1);
2. Knowledge, on a general level, of what blockchain technology is (Chapter 2);
3. Knowledge of factors that lead to success or non-success of the project (Chapter 3); and
4. Organisational maturity and capabilities to drive the project (Chapter 4).

Despite passing all the other hurdles, some blockchain technology projects may still fail. Perhaps despite meeting all of these factors blockchain is still the wrong choice for the specific need, project, or service. Perhaps the underlying premise of the service or understanding of the user need is flawed. Perhaps priorities or key staff have changed. There are countless reasons a technology product may fail to live up to its full potential, and oftentimes, this is the fault of no one person or thing in particular.

However, to maximise the chances of success, it is important to make informed design decisions. These could include deciding whether to use blockchain at all or determining what constitutes success in the future. In addition, much could be done to deflate overblown expectations surrounding blockchain technology projects from the outset and chasten marketing efforts to immediately sell pilot projects as success stories when it is unclear that they are indeed successful currently or will be in the future. These are not the only roadblocks that governments need to overcome. In general, public sector organisations still have much room for improvement in their digitalisation activities and in reaping the benefits of digitalisation efforts (digital maturity). Blockchain technologies often encounter the same siloed and complex infrastructures and operating environments as any other technology that may enter an organisation. Moreover, incumbent or legacy technologies and process often get in the way of new efforts.

When embarking on this research effort, we thought it would be much easier to find clear successful use cases and projects that were documented publicly, already in a deployed phase and had grown credible user bases. This was not entirely the case. Indeed we primarily encountered pilots that had fizzled out or were struggling. If we have overlooked some released projects, where public sector service delivery is using blockchain in disruptive ways and has garnered large documented user bases, please contact the OECD or the authors;[44] we are keen to hear more and to continue research efforts in this area.

The pervading sentiment is that the public sector is still not much closer to developing a killer blockchain application than it was in 2018 when the OECD published *Blockchains Unchained: Blockchain technology and its use in the public sector*.[45] Only time will tell whether blockchain technology will be able to live up to some of its hype in government, or if we will always fall short of this technology's lofty expectations.

To help provide clarity on this and to move the public sector closer to fully understanding the potential and utility of blockchain technologies, the following questions are posed for future work in this area.

[44] You may reach us at opsi@oecd.org.

[45] http://oe.cd/blockchain.

- How can successful private-sector use cases be leveraged, for example from supply chain and banking, to deliver public services?
- What core parts of the blockchain should be delivered as private platforms and what as public infrastructures? How is this question decided for these services? Currently, it seems that each use case is resolved individually. This question becomes pressing when looking into, for example, the Estonian experience, where a number of core digital public services are relying on decentralised technology.
- Is there tension between disintermediating the government as a public service provider and the idea of government earning trust via their democratic processes? It seems that current incremental blockchain implementations do not trigger this concern, but future disruptive ones might.
- Should public sector actors prioritise evolutive or disruptive blockchains? Currently, it seems that evolutive approaches are in governments' good graces, and more risky disruptive projects are being shunned.
- Currently, there are several large-scale infrastructure projects underway based on this technology (EBSI is one such project in Europe, but globally there are a number of them). How are these services being launched and how are they getting users on board?
- What are some of the killer applications for public sector blockchain? Once we have them documented in a credible way, it is easier to leverage them for future blockchain success.

Appendix A. Case studies: Blockchains on the frontlines

Groningen municipality (Netherlands) and Stadjerspas vouchers: Success despite blockchain

Issue

How should municipal organisations experiment with blockchain technology? Groningen is a mid-sized European municipality in the northern Netherlands. The city is young and growing fast and it has a well-developed start-up culture and an advanced digital scene.

The region hosts an important annual tech start-up hackathon called Odyssey where private and public organisations come together to collaborate on concepts related to societal and industrial digital innovations. In recent years, there has been a strong blockchain emphasis. The city has a strong track record of innovating with novel technologies such as blockchain.

Response

Blockchain technology has been implemented in the municipality through (at least) six pilots from 2016 to 2019: 1) a voucher system for individuals to participate in cultural and sports activities (proof of concept), 2) a digital vote-counting system for use during local/national elections (proof of concept), 3) a system for sharing of parking rights between individuals in a neighbourhood (concept), 4) a system for registering citizens who are in debt (creditors have access to the blockchain and can check to see if potential borrowers are already in debt) (concept), 5) an application for citizen requests for subsidies (concept), and 6) a system that enables inhabitants who produce extra electricity to sell it to lower-income inhabitants (concept).

The pilots were small-scale projects with a few people involved; four pilots were on a conceptual level (concept), while two have been set up and run for some time (proof of concept). In those pilots, when the technology was developed and tested (proof of concept), the technical development was outsourced to external companies.

The pilots were implemented in the different parts of the organisation, and the local hackathon served as an important filtering mechanism for ideas and provided publicity to those ideas that fared well in the competition. One of these projects has reached a wider user base: It is called Stadjerspas (“City Pass”).

Results and impact

Stadjerspas[46] is a voucher system that provides discounts for municipal services to specific low-income citizens. The original version was developed by a small local start-up called Dutchchain. Citizens apply Stadjerspas from the municipality and use a mobile device QR code as a voucher (when a specific QR code is read by a service provider, an underlying permissioned blockchain smart contract infrastructure checks the voucher's validity). Payment from the municipality to service providers happens later. The aim for the system is to use a phone app and digital service for more precise allocation of public funding, reduce fraud in transactions (especially double spending vouchers), and ensure more cost-efficient service.

The system has over 20 000 registered users and is continuously used to cash over 4 000 vouchers monthly. Thus, the system fulfils the requirement of an active system with a large user base. However, scaling later led to shifting away from using blockchain technology as a basis for the underlying infrastructure.

Challenges and lessons learned

Even though many municipal stakeholders themselves have voiced their scepticism of this, Groningen can be seen as a digitally mature blockchain organisation. Currently, the expertise is scattered in the organisation, and there is heavy reliance on external technology providers, but the municipality has been able to experiment with the technology and learn important lessons on what does and does not work.

However – and now comes an important lesson from Stadjerspas – the underlying blockchain technology has undergone several iterations, because there is no particular reason why Stadjerspas must use blockchain. Already, the initial developer, Dutchchain, moved away from the technology for a while to replace large parts of the backend infrastructure with a more traditional database structure. At the time of writing, the technology provider for the voucher system has changed. Public procurement documents for the system do not require blockchain, so the vendor has shifted to using a more traditional approach to the vouchers. To summarise, this project does not fulfil the main requirement – even though blockchain technology **is viable** for this project and service, **it is not valuable or vital**.

However, we consider this a success story of blockchain-based service, because the service was running for three years or so on blockchain, even though ultimately it was replaced with more traditional technology. The service does not fulfil requirements of being truly disruptive: The blockchain is only part of the infrastructure.

It is also noteworthy that the setting in which these municipal vouchers were used did not really disintermediate government – in fact, the entire service relies on the public sector to verify that the individuals are entitled to the service and providing the vouchers. Digitalisation of the vouchers was however a major improvement on the traditional work process.

BlockCerts (Malta) academic certification

Issue

Academic certificate fraud is a large global issue. The data architecture is siloed and scattered across universities and various government agencies. There are other similar approaches that use the same

[46] For a more in-depth description and architecture of the system, see, for example, (Allessie et al., 2019[18]).

technology and standard, but this early case was selected for this report among several candidates[47]. Another well-known example is the open source platform OpenCerts [48]

Response

The Maltese Ministry for Education and Employment is an innovative branch of the Maltese government that wanted to implement blockchain technology in a controlled environment. There was a clear motivation from the start to support self-sovereign identity – a solution that gives citizens more control over their own data.

The ministry started the project in 2017 based on earlier work involving open certification standards at MIT and Learning Machine.

Results and impact

The idea of the blockchain-based service is to provide users with an app (and appoint a specific university to issue a credential) that would contain a wallet that holds the academic certificate. The university would also hash the certificate to Bitcoin (or, depending on the setup, to some other) public ledger so that it could be later checked if needed. Users of the app would have control over their own records.

For third-party users that want to use the certificate, it would be possible to validate a specific certificate from BlockCerts Universal Verifier that checks the certificate from the Bitcoin ledger, but of course, other designs (and blockchains) would also be possible.

This or similar systems have been implemented all around the world by issuers of academic certificates (for example, MIT, in Mexico, in Argentina, in the Philippines, etc.). Early implementations were more limited pilots, but current implementations are growing.

Challenges and lessons learned

An interesting characteristic of this project is that the technological implementation is relatively straightforward and easy to grasp. It could also be implemented using several different technologies.

Several of these systems have been deployed, so the technology **is viable.** It seems that increased control over the identity wallet and ability to prove credentials that would give users more control over their data **is valuable.** On the other hand, incumbent university academic credential systems are working, so there is little direct incentive for universities to invest further in these technologies. Is blockchain **vital** for this? Similar services could technically be designed in a more centralised fashion if they could get hold of the different records. However, the self-sovereign consent system seems like a very good fit with the

[47] See U.S Dept. of Education report Connected Impact: Unlocking Education and Workforce Opportunity Through Blockchain (https://ipfs.io/ipfs/QmdEnhQcWHTY4ndotRs1YRpeTdjZGAyisHz8bugfYidkP2).

[48] The Singapore Government Technology has partnered with the Singapore Ministry of Education, SkillsFuture Singapore and local academic institutions to develop OpenCerts. OpenCerts is an open-source platform that education institutions can use for issuing digital academic certifications. The solution reduces the need for schools to issue paper certificates and the process of checking a certificate's authenticity is made easier. The digital certificates are designed to be tamper-proof; once a certificate is created, the data is converted to a hash and stored on the Ethereum blockchain. Locally, OpenCerts has been adopted by 18 local institutions and schools. The technology has been extended in the area of maritime trade with TradeTrust, vocational licenses for unmanned aircraft pilots, and HealthCare with HealthCerts for use in international travel. Internationally, the technology has also been used for issuance of digital certificates in Canada, Indonesia, Japan, Lithuania, Malaysia, Philippines and Thailand, for both educational and vocational training certifications.

technology and would likely meet less resistance from the user side. In terms of decentralised trust, there still needs to be some kind of system to guarantee the legitimacy of those actors that issue the certificates.

From a governance perspective, the holder of the records (such as the university) is the key actor – they can usually make decisions on complementing ways credentials can be issued relatively independently, although there are clear regulative and legal constraints on how this kind of system can be built, and these might vary for different legislations. Institutions can then proceed to issue the credentials. This removes some chicken-and-egg-type problems other public sector blockchain deployments have encountered.

However, the ultimate test for this kind of system is really the downstream usage of the credentials – i.e., what novel business value is generated and what business models can capture the value of the blockchain-based issuance of academic credentials. Whether these initiatives are successful or fall out of use is contingent on the service ecosystem that is facilitated and emerges for these services.

Lantmäteriet (Sweden) and property transactions: Suspended as planned, but running into legal hurdles

Issue

The traditional real-estate transaction settlement process is very slow and not transparent. There are many actors in the process and numerous steps in the workflow. Registering the transfer by the authorities can take up to six months. Many of the issues are related to lack of trust between the actors. Digitalising this process would thus have significant economic impact[49].

Response

The Swedish authority that is responsible for property transactions, Lantmäteriet, has been part of a consortium that has been developing, since 2017, a permissioned blockchain-based system to digitalise and facilitate the transfer of land titles. The idea is to provide a shared and more transparent workflow. The identification of the actors in the system is done using a mobile device.

There is plenty of documentation on the project, including efforts to export such a system for digital legislations. The project is documented quite clearly in earlier external reporting[50].

Results and impacts

The project was suspended in 2018-2019 when it reached its initial goal of providing a pilot that enabled property transfers. It cannot thus be considered a success in the sense of garnering a large user base (this was not the project's ultimate goal).

However, as one of the early pioneering projects, it can be seen to have changed how people recognise the potential of asset transfers. The project was also highly ambitious and contained disruptive elements far beyond the Lantmäteriet agency.

[49] The consultancy company for the project, Kairos, claims the cost savings could be up to EUR 100 million. "The Land Registry in the blockchain - testbed." Kairos Future, March 2017. https://chromaway.com/papers/Blockchain_Landregistry_Report_2017.pdf.

[50] Initial land registry report: http://ica-it.org/pdf/Blockchain_Landregistry_Report.pdf. Second report: https://static1.squarespace.com/static/5e26f18cd5824c7138a9118b/t/5e3c35451c2cbb6170caa19e/1581004119677/Blockchain_Landregistry_Report_2017.pdf.

Challenges and lessons learned

So, would you need blockchain for this service? This is not an easy question to answer. Blockchain **is viable** here – especially if it is compared to non-digital asset transfers that consist of too many steps. Any digitalising effort in this space seems valuable: Blockchain would bring the additional benefit of a decentralised architecture, but it does not seem obvious from the outset what the added blockchain value here would be compared to some other deployment.

Is it vital for this? This system would be very difficult to facilitate by one actor (and other actors would perhaps not like giving up this marketplace), unless the actor was Lantmäteriet. However, the system relies on Lantmäteriet to provide guarantee landownership and the conducted transaction process being seen as valid.

One of the main concerns raised by the project was the need to recognise digital signatures better – this kind of system would be reliant on this. Reporting by Lantmäteriet also raises several issues related to privacy and data security – especially brought by the GDPR.

Tel Aviv (Israel): Local currency gets pulled amid regulatory concerns

Issue

Place-based local currencies have been discussed and used for decades, but digitalisation makes it easier technically for cities to issue them. Local currencies could have several purposes such as rewarding specific behaviours. Examples of possible local currency uses in this case were related to economic growth and local entrepreneurship.

Response

Tel Aviv-Yafo launched a "Digital City currency pilot" in May 2019 with several other cities. The project, which was in turn externally piloted by a Gibraltar-based blockchain start-up called Colu (DLT), was funded from several sources, among others by an ICO in 2018 (consequently, the coin lost 90% of its value, and – in a highly unusual move – bought back its own ICO coins[51]).

Our interest here is in the collaboration with the public actor that had the aim of "reducing the cost of living, strengthening the local economy, and increasing social responsibility and civic identity." The system issued the TLV Tel Aviv coin (not to be confused with the ICO coin called a CLN token). The users could trade issued coins through a website, as well as iOS and Android apps.

The company was not running the TLV token system on a blockchain, but on a centralised server. However, the company had clearly indicated its aim to move into a blockchain system (Ethereum) before it pivoted away from cryptocurrency.

Results and impacts

The project was abruptly pulled in September 2019, citing regulatory uncertainty[52] as one of the reasons, and the company proceeded with the ICO coin buyback programme (subject to know-your-customer and

[51] For more news coverage about this episode: https://cryptonews.com/news/ico-project-that-ditched-blockchain-finalizes-its-token-buy-5465.htm.

[52] In a post entitled "Concluding Blockchain Project, Colu DLT Purchases CLN Tokens; Colu Group will Focus on Growing Municipal Partnerships," the company writes, "In recent months, the Colu Group has seen extensive growth in its work with municipalities across the globe, including significant opportunities which it wishes to pursue.

anti-money laundering checks). Though unrelated to this event, the Bank of Israel declared later that a digital shekel was not on their radar and would not be accepted in the near future due to a number of reasons.[53]

Challenges and lessons learned

This project was run independently of the city activities but can be seen as infrastructural. We do not have the full details of the decision to stop the currency, but this does serve as a good reminder of the need to guarantee regulatory compliance and some of the issues related to cryptocurrencies in local settings. Based only on the comments from the central bank and the decision to pull the local currency, we are not yet convinced that it **was viable** for this use case – even though the organisation was technically able to issue and trade coins.

Voatz (US): Blockchain-based complementary distance voting

Issue

Distance voting using a mobile app has been suggested as a way to digitalize the selection of representative democratic process, increase interest and participation in elections, and provide an easier way for voters to participate in elections. Decreasing the cost of elections and getting the election results faster are two other purposes that are often cited. At the same time, distance voting raises election security and election interference issues for election systems design.

Response

Voatz is a Boston-based private internet voting company started in 2016 that has run initial blockchain-based elections. Their main product is a mobile voting app also called Voatz.[54] The system uses biometric information to set up user accounts, and the infrastructure servers are based on the Hyperledger blockchain. The system is intended for complementary voting, for example, by US voters who are overseas.

The company has run a number of high-profile pilots in the US, but it also attracted criticism from the security expert community over transparency concerns with the auditing programme and was consequently removed from HackerOne, a major vulnerability bounty programme.

Results and impacts

Voatz has been used in more than 60 election pilot projects as a complementary service[55]. Most of the pilots have been relatively small (voters in hundreds). Due to the increased need for distance voting, Voatz has also been used in virtual conventions.

However, the CLN platform which Colu DLT had been developing and supporting poses both regulatory and technical challenges to this work. Colu Group has decided to align its operations accordingly." https://web.archive.org/web/20190910065141/https://cln.network.

[53] https://www.financemagnates.com/cryptocurrency/coins/no-digital-shekel-anytime-soon-says-bank-of-israel-exec.

[54] There are also other blockchain initiatives on voting approaches. One interesting example comes from Estonia: https://www.ivotingcentre.ee.

[55] https://blog.voatz.com/?p=1327.

Challenges and lessons learned

Most of the issues raised regarding auditing and election security are not directly related to blockchain technology: Secure distance voting is an extremely difficult and complex use case for any technology.

Based on the pilots and users, it seems that complementary distance voting would be **a viable**, but not valuable or vital use case, because there are already a number of voting apps that do not rely on blockchain. Theoretically, blockchain-based infrastructures would have several attributes that support their usage in voting. However, as long as there are so many election security concerns, it is difficult to say much more about the suitability of the specific technologies.

Estonian Information Systems Authority (RIA) and KSI Blockchain (Estonia): Private blockchain-backed government records

Issue

Estonia was a target of large-scale cyberattacks in 2007. These attempts made it clear that government data needed to be secured against possible insider threats. These include, for example, healthcare registries, property registries, and so on. There was a need to secure three things: (1) that government can trust internal data in all circumstances, (2) that integrity of the data can be enforced, and (3) that verification of the data needs to be in real time.

Response

To solve this issue, Estonia has been investigating hash-linked time stamping to guarantee data integrity. The first efforts were made public in 2008, even before Satoshi Nakamoto's Bitcoin whitepaper came out. Succession registry was rolled out in 2012—one of the early successes that relied on blockchain-backed technology.

Results and impacts

KSI blockchain is, at the time of writing, protecting the healthcare registry, property registry, business registry, succession registry, digital court system, and so on.[56]

A key actor in these efforts has been the Estonian Information Systems Authority (RIA), which provides these services for the state. State agencies are responsible for deploying blockchain-backed technology by using SDKs and other pre-built tools.

Challenges and lessons learned

There are two main technical benefits from this data: immutability backed-up by blockchain and consensus process over the data. It should be noted that no actual data is stored on blockchain and that is why Estonian officials are careful to say that the service is a blockchain-backed service rather than a blockchain service. The blockchain network is used only to guarantee the integrity of data and log changes, not for storage.

The Estonian government has several different use cases in this area. For some of the use cases, KSI blockchain is only a part of guaranteeing the archiving and versioning. For some other use cases, it is the main and only guarantee of data integrity. For the complementary use cases, blockchain can be seen as

[56] Check https://e-estonia.com/tag/blockchain for more information about the different kinds of blockchain-inspired approaches.

viable and valuable. For the use cases where only a blockchain-backed system is used, it can be argued that the blockchain is vital.

Swedish unemployment agency and Axa insurance agency (Sweden): Digitalising the unemployment certificate process

Issue

The insurance company Axa wanted to digitalize the payments of employment insurance and one of the pre-requisites is that a person needs to be registered as an unemployed jobseeker with the state employment agency. The transaction process is very simple, but the legal framework requires bureaucracy. During the non-digital process, a person needs to visit the employment office to get the certificate (identity check is necessary), and the certificate is a paper certificate that can then be sent to the insurance company. Due to legal constrains, the employment agency cannot directly share the jobseeker's status with a third party. This will then entail a physical monthly visit to the employment agency—not an effective process.

Response

A blockchain solution is used to issue a digital unemployment certificate to the user's wallet phone app about the unemployment status of the user. The user can then give Axa access to the wallet to retrieve the certificate (and sign), and the payment to the user can be made.

Results and impacts

The system is currently installed with approximately 1 000 users, but exact information about the usage is not released currently. The system architecture is mostly on the Axa-side, and the unemployment agency has two key data points: jobseeker consent and unemployment status (whether the person is a jobseeker).

Challenges and lessons learned

This solution is mostly on Axa's side (private), so it is a bit debatable how public sector orientated this use case is. However, the information comes from the government-service side. In this use case however, the private-sector insurance company controls much of the computing environment. This information could be potentially used for a number of downstream services, such as educational and political initiatives, social benefits, and so forth. Engaging private-sector actors relying on individual consent was seen as an important part of the expansion of service.

Such a system could be built on technology other than blockchain. However, the approach of consent control gives the user more control over with whom the certificate can be shared. This architecture would be difficult to control with some other system, so blockchain can be considered vital for this service.

Government of Karnataka (India): Post matric scholarship certificate - with blockchain

Issue

Verification of documents is an inevitable part of the student lifecycle when moving from one level of education to the next. Documents that are generated in one phase become input data for the process of

verification in subsequent stages. Traditionally, the process requires in-person visits, identity checks, and the exchange of documents – often a bureaucratic process where fraud is not uncommon.

Response

The government of Karnata (India) offers a blockchain solution to support post-matric attestation and scholarship. The current systems requires the user to initially upload the document digitally and then physically submit the document for verification.

This solution relies on the use of Aadhaar E-sign for the identification of users.[57] Statutory authorities authenticate the documents. Verified documents are then stored in perpetuity and can be accessed as needed. Users can retrieve their verified documents and manage consent for third-party access to the documents.

Results and impacts

The system went live 1 November 2019 and by March 2020 contained 1.35 million certified documents. More than 4 500 higher educational institutions have been trained and are using the technology, and over 20 000 officers have verified and electronically signed documents. In total, these documents have been used as identification documents in the disbursement of USD 260 million in scholarships.

Challenges and lessons learned

The real strengths, benefits and efficiencies of the system are only realised when certified documents are used multiple times and when it is possible to observe wide-scale usage of the documents by third-party actors.

Setting up the account and learning to use the system is time-consuming for users. Therefore, clear incentive to complete the process of setting up the account and uploading the documents is needed: in this case, access to scholarship funds provided that motivation.

From a system point of view, a similar system could be designed that does not rely on blockchain. However, blockchain provides a unique ability for the user to control consent in accessing the documents and is, in general, a more digital way for the user to re-use the certified documents. These benefits make the blockchain technology vital to this service. The overall process is a more transparent than a centralised approach would be.

[57] See OPSI's case study on Aadhar at https://oe.cd/innovation2018.

Appendix B: List of example blockchain use cases (that have users)

Service	Level	Examples that now have users	Link. Description. Issues to look into.
Local identity ("city pass")	Local	Groningen municipality (Netherlands) Stadjerspas see also 6.1	https://stadjerspas.nl Has over 15 000 actual users, but it is not exactly running on blockchain anymore.
Records (academic certificates)	All levels	Learning Machine (Hyland) Blockcerts, Malta, the US, etc. see also 6.2	https://www.learningmachine.com Number of users is unknown, and downstream data use is unknown. Acquired by Hyland on 1 Feb 2020.
Land title registry	National	Lantmäteriet (Sweden) See also 6.3	http://ica-it.org/pdf/Blockchain_Landregistry_Report.pdf Pilot was conducted and project then suspended.
Local currency	Local (several cities)	"Digital City currency pilot" (Israel) See also 6.4	https://web.colu.com/ Website and phone apps were trading coins when the project was pulled.
Distance Voting	All levels	Voatz (US) See also 6.5	https://voatz.com ("Used in over 60 elections.")
Storing hash of digital item (government records)	National	Estonian Information Systems Authority (RIA) and KSI Blockchain See also 6.6.	https://e-estonia.com/solutions/security-and-safety/ksi-blockchain/ ("Platform guarantees integrity of over 60 services")
Records (unemployment status)	National	Swedish unemployment agency and Axa insurance See also 6.7	https://jobtechdev.se (Around 1 000 users who have installed the wallet software)

Land title registry	National	Exonum and NAPR (Georgia)	https://exonum.com/story-georgia "1.5m land titles registered and time-stamped by Exonum (Bitcoin)." Number of users is currently unknown.
Mitigating and identifying fraud	National International	SETAM OpenMarket and electronic auctions of state property in Ukraine	https://exonum.com/story-ukraine "In the first five months after the implementation of Exonum, 4,000 auctions were successfully held on the blockchain, with a total sales amount of $24.5 million" (private blockchain and snapshots to Bitcoin). Permanently stores information about the sold items to reduce corruption.
Public procurement process	Local	Antwerp (Belgium)	https://antwerpen.digipolis.be/en Publishing procurement notifications and procurement process control. In use, but need more information about users.
Public procurement process	Local	Region of Aragón (Spain)	https://licitacion.aragon.es/ In limited testing: 24 public competions organised.
Storing hash of digital item (open data)	Local	Wien (Austria)	https://smartcity.wien.gv.at/site/en/digitalcity-wien/ "solution went live in December 2017, approximately 350 datasets have been secured on the blockchain networks." Downstream usage currently unknown.
Invoice tracing system	Local	Guangdong (China)	https://www.thebeijinger.com/blog/2020/03/10/beijing-roll-out-new-blockchain-system-fapiao "The Guangdong municipality has now registered more than 10 million blockchain invoices amounting to more than RMB 7 billion, with over 7,000 companies able to access the blockchain invoicing system". Need more information about the users.
Company registry information	Local Regional	OrgBook BC British Columbia (Canada)	https://orgbook.gov.bc.ca/en/home "1.3 million active legal entities, 2.4m verifiable credentials" Need information about users.

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