OECD Working Papers on Public Governance No. 31

State of the art in the use of emerging technologies in the public sector

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https://dx.doi.org/10.1787/932780bc-en

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Key Findings

Digitisation is viewed as a new source of growth, efficiency and relevance in today's increasingly digital world. Governments and public sector organisations are embracing new and emerging technologies for developing innovative approaches to policy making, service delivery and public value creation. Building on the insights and data collected from 20 OECD member and partner countries, this working paper tries to capture the current state of the art on public sector adoption of emerging technologies, with a specific focus on AI and blockchain. It will discuss some of the associated challenges and opportunities and provide a preliminary set of policy guidance. Key findings include:

Emerging technologies such as artificial intelligence (AI) and blockchain hold considerable potential for making the public sector smarter, i.e. more agile, efficient, user-friendly and, as a result, more trustworthy. For instance, AI can be used to deliver more effectively personalised services and to foster *citizen engagement* with public institutions, through the design of human-centric interfaces; enhance *operational efficiency* and the quality of administrative procedures through increased automation of physical and digital tasks; and, to enable greater *predictive capabilities* for better decision making and policy outcomes, through the use of algorithms designed to uncover trends and patterns in large volumes of data. Blockchain, if properly applied in a public sector environment, yields significant benefits in terms of *increased transparency, accountability and security* through stronger data integrity and immutability across agencies; as well as *efficiency gains* resulting from the reduction of processing time and costs thanks to contract automation (so-called 'smart contracts').

Governments can play multiple roles to strengthen national research capacity and translate technological progress into public sector applications that deliver public value:

- *Government as a convener*, through the adoption of an overarching strategy that showcases high-level political commitment. Many countries have announced national strategies and policy initiatives to advance the digital government agenda and ensure a leadership position in emerging technologies like AI.
- *Government as financier*, typically through the provision of direct or indirect funds to support the research, development and adoption of emerging technologies.
- *Government as direct user and co-developer*, together with public sector organisations, can act through innovative procurement practices, or as a proactive co-developer through public-private partnerships, and other forms of collaboration, to build tailored solutions.
- *Government as a regulator*, as the diversity of challenges raised by the digital transformation calls for a reassessment of existing policy frameworks, holistic approaches to ensure policy coherence and international regulatory co-operation.

Governments worldwide are experimenting with emerging technologies to better meet the needs of public-service users and steward coherent use of resources to maximise public value. These projects increasingly centre around the applications of AI and more recently of blockchain. They fall under four broad areas: (*i*) enhancing the quality of

welfare services; (*ii*) increasing operational efficiency and security; (*iii*) preserving the environment, natural capital and climate resilience; and (*iv*) making data-driven policy decisions for better governance.

Specifically, governments exploring the role of AI tend to focus on projects where human-machine interactions can provide better user experiences and/or free up resources for higher value-adding tasks. Experiments are currently concentrated in the health, transportation and security sectors. Common use cases for blockchain in the public sector have so far addressed issues related to digital identity and certificates, personal records authentication, welfare benefits or entitlements, asset registries, and inter- or intragovernmental transactions. They generally leverage three core features of blockchain in terms of recordkeeping and authentication, value transfer, and smart contracts.

Governments face multiple challenges in how to incorporate these emerging technologies for public purposes. A review of existing practices has identified three types of challenge, including: *technical and practical challenges*, such as the availability of quality data and lack of common standards; *resource and capacity constraints*, typically inadequate investment and funding, and low digital literacy and skills shortage in the public sector; and *institutional, legal and cultural barriers*, notably regulatory gaps and insufficient political and institutional buy-in. Among these, the absence of common standards and suitable legal frameworks are the most quoted obstacles, in part due to growing concerns around fairness, transparency, data privacy and accountability/legal liability arising from the introduction of AI and blockchain.

A paradigm shift will be essential to adopt systematic and whole-of-organisation approaches to the digital transformation of the public sector. Meaningful, sustainable and resilient use of emerging technologies within governments and public sector organisations requires strategic vision and leadership commitment, suitable organisational and governance frameworks, new working methods and capabilities to support agile and efficient design, implementation and delivery of public policies and services. Notably, political support and engagement with the private sector have been identified as two major enablers for public sector adoption of emerging technologies.

Going forward, governments could consider focusing actions on the following key areas, indicated in the OECD Recommendation on Artificial Intelligence, to integrate emerging technologies in their overall digital transformation agenda:

- ***Establishing a suitable governance framework to facilitate the use of technology in public sector***. Such framework could consist of: whole-of-government approaches that secure coherence among different arms of the administration; a core group dedicated to coordinating planning and implementation; and structured forms of engagement with key stakeholders in the relevant ecosystems;
- ***Promoting synergies across public sector organisations*** that can support a purpose-oriented and problem-driven adoption of AI and blockchain, as well other ETs, to improve policies, processes and services to the benefits of citizens and businesses. ***Acquiring adequate competencies and capacities within the public sector***, starting with building a dedicated pool of civil servants and experts capable of identifying appropriate technologies for rethinking a given task, purpose or need;
- ***Experimenting and piloting***, for instance by identifying a portfolio of priority projects to test agile approaches and spot scale-up opportunities where the adoption of emerging technologies would be most meaningful, feasible and cost-efficient ;

- ***Reassessing existing legal and regulatory frameworks*** to address the social, ethical and legal challenges raised by emerging technologies;
- ***Stepping up collaboration with the private sector*** to lever industry progress in emerging technologies and support open innovation;
- ***Jointly participating in international and/or regional projects***, developing synergies among governments for research, testing, implementation and monitoring of ET in this public policy stream.

1. Note from the Secretariat

This Working Paper was prepared by the Reform of the Public Sector Division of the OECD Directorate for Public Governance and the Working Party of Senior Digital Government Officials (E-Leaders).

This Working Paper is intended to highlight the main opportunities and challenges for the use of emerging technologies (ET), and in particular emerging digital technologies, in the public sector. The analysis included shall contribute to a better understanding of the implications, requirements and impacts of using ET to foster the digital transformation of the public sector, in line with the main findings of the analytical work conducted by the Thematic Group (TG) on the Use of Emerging Technologies (AI and blockchain). Based on the first results of the analysis of evidence collected in 20 countries, the paper offers a few insights on the state of the art on the strategies and practical examples on how governments are attempting to integrate ET in the public sector.

This paper is a key contribution to the broader analysis of the OECD on the implications of the digital transformation affecting economies, societies and governments, framed under the horizontal project Going Digital (OECD, 2019[1]). The paper complements existing work streams on blockchain (Berryhill, Bourgery and Hanson, 2018[2]), and AI (OECD, 2019[3]).

This document was drafted by the Agency for Digital Italy staff and experts (Enzo Maria Le Fevre, with the support of Elisa Petrucci, Pietro Marchionni, Claudio Biancalana and Nanni Hiltunen, under the supervision of Daniela Maria Intravaia) together with the OECD Secretariat (Barbara-Chiara Ubaldi, Deputy Head of Division and head of the Digital Government and Open Data Team in the Reform of the Public Sector Division, Public Governance Directorate). Colleagues from within the OECD including Jamie Berryhill, from the Observatory on Public Sector Innovation, Alistair Nolan, Laura Galindo-Romero, Karine Perset, Gallia Daor and Nobuhisa Nishigata, reviewed and provided comments. Irène Hors, Deputy Director of the Public Governance Directorate, provided strategic advises and João Ricardo Vasconcelos, digital government policy analyst, served as the lead coordinator of the document, under the supervision of Barbara-Chiara Ubaldi. The document benefitted from the editorial support and substantive contribution provided by Chan Yang, Strategy and Business Development Consultant on Technologies for Impact.

The document builds on the output produced by the E-Leaders Thematic Group on Emerging Technologies (Artificial Intelligence and Blockchain) presented in the meeting of the Working Party of Senior Digital Government Officials (E-Leaders), hosted by the Korean government in Seoul on 30-31October 2018. It benefited from the precious experience and active collaboration of all the countries members of the mentioned E-Leaders Thematic Group: Italy (coordinator of the Thematic Group), Argentina, Australia, Canada, Chile, Colombia, Estonia, Finland, Greece, Korea, Latvia, Netherlands, New Zealand, Panama, Portugal, Slovenia, Spain, Sweden, United Kingdom, Uruguay, and the European Commission (DG Connect and DG Digit). The active support and contributions by each one of the Thematic Group members involved was crucial to the elaboration of this document and the Secretariat would like to express its gratitude to these countries for their commitment and continuous support.

1.1. Scope and structure of the paper

Discussions around emerging technologies and their implications for the public sector are high on the global agenda. Governments have started developing focused strategies and devoting specific budgets to advance the use of specific applications of these technologies, both in the public and private sectors.

One of the main challenges that governments face is the integration of emerging technologies into efforts of public sector modernisation. The objective is to overcome sectoral silos and use emerging technologies as part of overall public sector reform and development strategies. Such a challenge is not novel for policy makers. The OECD Recommendation of the Council on Digital Government Strategies (OECD, 2014[4]) suggests a set of policy actions aimed to support an uptake of digital opportunities that advance the global political agenda of a country based on a whole-of-government approach, rather than one driven by sector-based approaches which still prevail in many parts of the world. The OECD Recommendation on AI, adopted in 2019, further recommends national policies and international co-operation for fostering trustworthy AI, including in the public sector.

For this reason, the TG considered it essential to adopt an evidence-based approach in order to understand how each participant country is introducing ET solutions into public administration and government services. It shares in particular insights into national strategies and approaches on ET development and implementation, providing an initial picture of the main opportunities and challenges for the use of ET in the public sector. The paper analyses the main actors involved, as well as the major enablers and constraints to the use of these technologies in the public sector with a government-wide perspective.

With this purpose, this paper maps the current use of ET in the public sector across 18 OECD member countries and 2 non-member countries[1]. The mapping is not aimed at ranking countries' performances, but at identifying strategic approaches, key actors and existing networks in the sector, sharing good practices or on-going experiments among OECD countries and identifying the main implications for countries at different stages of use of disruptive technologies in the public sector.

Input from the European Commission, which took part in the work of the TG, complements the analysis based on country evidence.

The paper includes the following sections:

- Section 2 sets the context to understand the main advances in emerging technologies, with focus on artificial intelligence (AI) and blockchain, and discusses their scope, development and relevant features for public sector uses.
- Section 3 illustrates recent trends in the adoption of AI and blockchain technologies in the public sector, based on empirical findings from the 20 TG countries. Specifically, it reviews the presence of national strategies and main actors tasked with advancing the digital government agenda; presents the level and forms of government support for encouraging public sector uptake of ET; and finally, maps the main areas of AI and blockchain adoption by public sector organisations.

[1] See Annex A

- Section 4 discusses the major obstacles to the adoption and application of emerging digital technologies in the public sector. It then offers a set of preliminary lessons learnt on key enablers and success factors, and ends with a few questions for further research to help governments better navigate their digital transformation agenda.

1.2. Methodology

The document presents the results of the analysis of the state of the art on ET uptake by participants of the TG, with the aim to provide a picture of the main related opportunities and challenges.

The analysis covers the period from January 2018 to July 2019. It includes the gathering of evidence collected through a questionnaire[2] conducted among TG participants, to identify and share existing practices and on-going experiments, and to highlight the main challenges faced by countries at different stages of adoption of ET.

In addition, the paper benefits from a mapping of ET[3] in the public sector. It analyses how these technologies have been integrated and contributing to improving the quality of public policies and services.

For the sake of clarity, we specify that countries are always mentioned in alphabetical order.

[2] See Annex B

[3] See Annex C.

2. Brief introduction to emerging digital technologies

Digitalisation trends over the past three decades have offered increasing opportunities for the public sector to develop innovative approaches to policy making, service delivery and public value creation. From mainframe computing in the late 1950s, to the introduction of personal computers in the late 1970s and the advent of the internet and open networks in the 1990s, governments and public sector organisations have a long history of using technologies to improve internal and external collaboration, better plan resources and procurement operations, inform decision-making and reform service delivery, in line with the changing needs of citizens and businesses (OECD, 2003; 2005; 2009; 2011).

As an emerging technology (ET) can quickly become mainstream or disappear altogether depending on its pace of development, adoption and whether it is superseded by a better technology, this working paper has adopted the following definition: "those technologies of recent adoption, or currently under development, offer disruption to the current operating models of government and allow for innovative solutions for public policy and service delivery, and to the socio-economic context overall.[4]" A common list of ETs[5] has been prepared by the Thematic Group (TG) to guide the sharing of information about the solutions that are being integrated into the process of policymaking and public service delivery. This section will focus on two emerging digital technologies – artificial intelligence and blockchain, and discuss briefly their scope, development and relevant features for public sector uses.

2.1. Artificial intelligence (AI)

What is AI

There is no universally accepted definition of AI, partly because our understanding of what constitutes "intelligence" has evolved over time and entails a concept of a cognitive capability which is highly fluid.

The OECD has adopted the following definition of AI, "a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations, or decisions influencing real or virtual environments" (OECD, 2019[3]) (OECD, 2019[5]). It does so by utilising machine and/or human-based inputs to: i) perceive real and/or virtual environments; ii) abstract such perceptions into models through analysis in an automated manner e.g. with machine learning, or manually; and iii) use model inference to formulate options for information or action" (OECD, 2019[3]). AI systems are designed to operate with varying levels of autonomy. Box 2.1 describes the main phases of the AI system lifecycle.

[4] Daniele Rotolo (University of Sussex), Diana Hicks (Georgia Institute of Technology) and Ben R. Martin (University of Sussex) define ET as one bearing the following attributes: (i) radical novelty, (ii) relatively fast growth, (iii) coherence, (iv) prominent impact, and (v) uncertainty and ambiguity. (Rotolo, Hicks and Martin, 2015)

[5] See Annex C.

Box 2.1. The AI system lifecycle

An AI system incorporates many of the phases involved in traditional software development lifecycles and system development lifecycles more generally but contains specific features. The AI system lifecycle typically involves the following phases: *i)* 'design, data and models', which is a context-dependent sequence encompassing planning and design, data collection and processing, as well as model building and interpretation; *ii)* 'verification and validation'; *iii)* 'deployment'; and *iv)* 'operation and monitoring'. These phases often take place in an iterative manner and are not necessarily sequential. The decision to retire an AI system from operation may occur at any point during the operation and monitoring phase.

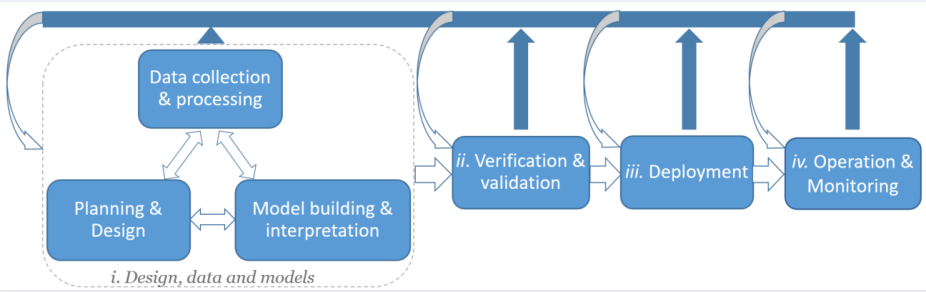
The AI system lifecycle phases can be described as follows:

i. **Design, data and modelling** includes several activities, whose order may vary:
   - **Planning and design** of the AI system involves articulating the system's concept and objectives, underlying assumptions, context and requirements, and potentially building a prototype.
   - **Data collection and processing** includes gathering and cleaning data, performing checks for completeness and quality, and documenting the metadata and characteristics of the dataset. Dataset metadata include information on how a dataset was created, its composition, its intended uses, and how it has been maintained over time.
   - **Model building and interpretation** involves the creation or selection models or algorithms, their calibration and/or training and interpretation.

ii. **Verification and validation** involve executing and tuning models, with tests to assess performance across various dimensions and considerations.

iii. **Deployment** into live production involves piloting, checking compatibility with legacy systems, ensuring regulatory compliance, managing organisational change, and evaluating user experience.

iv. **Operation and monitoring** of an AI system involves operating the AI system and continuously assessing its recommendations and impacts (both intended and unintended) in light of objectives and ethical considerations. In this phase, problems are identified and adjustments made by reverting to other phases or, if necessary, deciding to retire an AI system from production.



Source: OECD (2019c), *Artificial Intelligence in Society*. OECD Publishing, Paris.

AI developments: past and present

AI is not new. AI has gone through three springs of development. The first spring running from 1950s to mid-1970s saw research efforts concentrating on making intelligent machines and robots, following **logic-based approaches**. Early work on logical reasoning, character recognition and natural language processing was developed and AI gained ground as an area of interest.

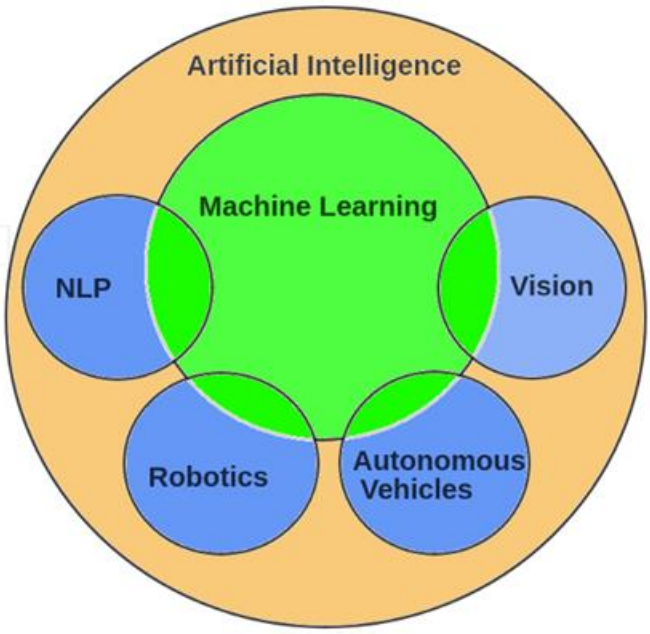
In 1958, Frank Rosenblatt, a psychologist in Cornell, created a pattern recognition model that forms the basis of today's complex neural networks (Rosenblatt, 1958). A year later, Arthur Samuel, an American pioneer in computer gaming and AI, coined the term "Machine Learning (ML)" devising one of the world's first successful self-learning checkers-playing programme (Samuel, 1959).

The second AI spring (1980-1987) was characterised by **knowledge-based systems** (e.g. expert systems), which, by definition, were computer programmes that answer or solve problems about a specific domain using logical rules derived from the knowledge of experts. Despite being very good at reasoning over narrowly defined problems, these systems failed to deliver learning and abstracting capabilities that many view as being major parts of intelligence. They were also difficult to scale due to cumbersome manual rules-writing processes.

Continuing technological progress over the past three decades have led to the third and current spring of AI development driven by **statistical learning**. Starting from the 1990s, technological progress had made the task of building systems driven by real-world data more feasible. The capacity of Internet as well as the entire landscape of digital devices that generate data streams for gathering large amounts of data (known as "big data"), and the increased availability of computing power and storage to process that data enabled statistical techniques (e.g. ML and Deep Learning) which, by design, derive solutions from data. Current AI systems are characterised by good performance in learning (e.g. categorisation tasks, facial and voice recognition), but do not yet have strong reasoning abilities to understand the context in which these tasks are taking place, or to abstract knowledge from one domain and apply it to another.

In recent years, ML has emerged as the dominant approach of AI technology (Figure 2.1). It is a statistical technique to teach machines to make decisions by showing them many examples of correct decisions, or by defining a set of rules and letting the machine learn by trial and error. Pedro Domingos, a researcher in ML at University of Washington, underlines the importance of ML as "learning algorithms […] that make other algorithms" (Domingos, 2015[6]). Other core areas of AI-related research include natural language processing (NPL), autonomous vehicles and robotics, and computer vision.

Figure 2.1. Approaches to AI



Source: Kumar (2018).

Relevance for the public sector

Certain AI approaches such as machine learning (ML) are already widely visible in our daily lives, from a Nest thermostat that learns from user preferences, to Pandora's music service that learns to recommend music, Bing's airfare predictions, Google's automatic language translator, or Yelp's system that helps users find a place to eat. As technology progresses, ML capabilities are likely to improve, possibly adding to future prosperity (GOV.UK, 2018[7]) .

This approach is also true for the public sector, where AI can play a pivotal role in supporting the public sector in its perpetual fight to simplify processes or increase their efficiency. The increasing demand for services that better answer to changing user expectations of responsiveness and personalisation, coupled with higher expectations on the role of the government in the digital age, requires a technologically mature public sector. For example, government should be able to support the application of the "Once Only Principle"[6] as a way to ease the interaction between citizens and the public administration. AI and data-driven innovation are supportive elements to bridge this gap.

The current wave of digital transformation in delivering policy and designing services follows from the e-government movement which preceded, and informs, it. By enabling governments to be digital by design, and capable of bringing the needs of users into the development of policies and services (OECD, 2014[8]), a digital government can use AI to deliver services closer to users' needs and preferences and thus have the potential to better

[6] It aims at ensuring that citizens and businesses provide diverse data only once in contact with public administrations, while public administration bodies take actions to internally share and reuse these data – even across borders – always in respect of data protection regulations and other constraints (TOOP, 2019[35]).

increase their wellbeing (Welby, 2019[9]). AI can be used to strengthen citizen engagement with public institutions; increase operational efficiency and free up resources for higher value-adding tasks; and enable greater predictive capabilities for smarter policy making and service provision.

However, there are still many challenges that governments need to overcome to secure an effective use of AI, such as data availability, interoperability, standards, and privacy, as well as security and ethical related issues. Considering the growing role of AI within public sectors, it is key for governments and regulators to review the role they should play to ensure a balance between encouraging AI to foster public sector innovation and improved public services, while protecting the public and service users' interests from potential unintended negative consequences of the use of these disruptive technologies.

Section 3.3. of the current working paper presents relevant sectors of the government where the uptake of AI and blockchain is rapidly taking place, highlighting the purposes benefits and challenges linked to the use of these applications in the public sector.

2.2. Blockchain

What is blockchain

While blockchain exists in many variants, it can be understood as a **distributed ledger** of transactions that is shared and written by a group of non-trusting or trusting parties in a network, not controlled by a single central authority.

Consider a ledger that registers and stores all transactions between users in sequential, chronological order. Instead of one authority controlling this ledger – like a bank or an escrow account - an identical copy of the ledger is held by all users of the network (OECD, 2018[10]). Content of the transactions is validated through a consensus mechanism, *i.e.* a protocol collectively agreed on by all network participants, which is verified and secured through advanced cryptography. Blockchain is one type of distributed ledger technology (Berryhill, Bourgery and Hanson, 2018[11]).

Several characteristics of blockchain technology may explain the depth of excitement people express. First and foremost, blockchain provides trust through **disintermediation**, *i.e.* replace the need for trusted third parties with technology and code. A central intermediary or governing institution has traditionally been required to establish trust and mitigate counterparty risk among a set of independent parties that seek to enter into a transaction or agreement with each other. While these centralised bodies have effectively fulfilled their function throughout large parts of human history, they have at times grown opaque, complacent, inefficient and costly to run. The risks of censorship, corruption and single point of failure have also intensified alongside the growing need for digitalisation.

The downsides of centralised control have remained equally acute even into the digital age. While the internet has vastly improved the flow of data, it has not changed how business is done. Intermediaries remain indispensable for transferring assets from peer to peer, which creates barriers to entry, accumulates wealth within the hands of few and excludes the have-nots from the system.

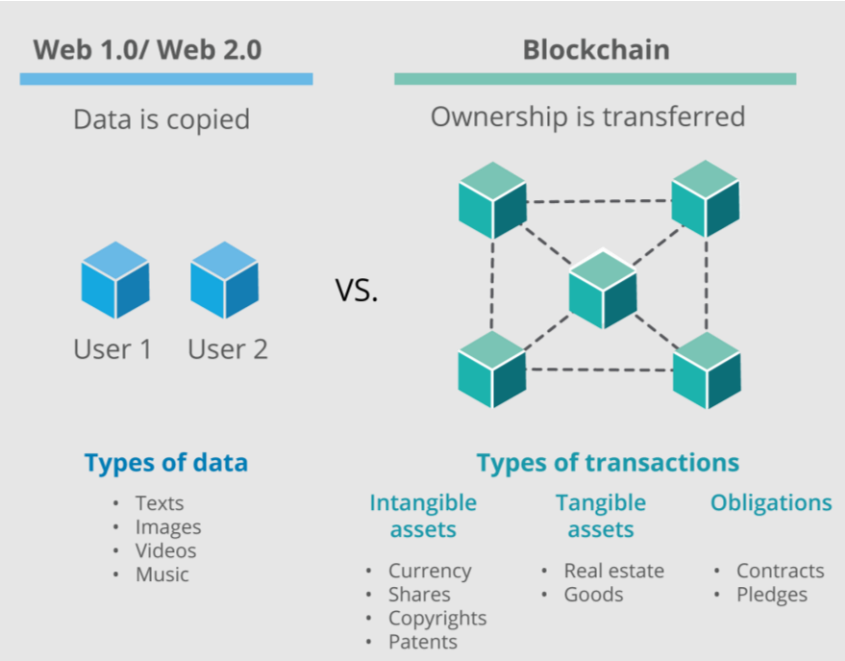
Blockchain can eliminate significant resource burdens by reducing this dependence on existing third-party intermediaries and their accompanying layers and costs. It can make near real-time settlement and verification of transactions. It also heralds the transition from

the first generation of the Internet to the second generation – from an *Internet of information* to an *Internet of value*, where individuals and businesses which otherwise have no reason to trust each other can reach consensus through direct peer-to-peer collaboration, cryptography and smart code (Tapscott and Tapscott, 2016) (Figure 2.2).

Second, although still in its infancy, if properly designed, blockchain offers the promise of stronger **resilience** against cyberattacks and IT system frauds than centralised systems, thanks to its decentralised nature which prevents single point of failure that is common to centralised databases. Security is a built-in design of the technology stack. As information is replicated simultaneously and kept in sync on all users of the network, if part of the network becomes faulty, there will always be another part that ensures continued availability of the system.

Third, blockchain is an **immutable**, censorship-resistant, append-only ledger. The association of cryptography, consensus protocols (*e.g.* proof of work/stake/authority, etc.) and collective/decentralised bookkeeping in principle guarantees that transactions are recorded irreversibly and permanently. In other words, there can only be one single version of the data/information that is visible to all participants in the network, although there is yet no way of authenticating the veracity of data/information protected in the blockchain. Some downsides include lack of sustainability, lack of interoperability, privacy protection and the right to be forgotten, hence the general rule is to never register personal information on blockchain.

Figure 2.2. Moving towards the Internet of value



Source: Deloitte (2017).

Blockchain developments: past and present

Blockchain builds on several underlying technologies that are long established in the space of computer science and cybersecurity. Between 1960s and 1980s, cryptographic foundations were laid with the development of hash function (a collision-free, and

irreversible digital fingerprint) and public-key or asymmetric cryptography (a cryptography system that uses pairs of key). These early day technologies provided confidentiality in the transmission of information.

The cypherpunk movement, advocating the use of strong encryption to preserve privacy, starting in the early 1990s put concerns of anonymity, privacy and freedom at the heart of their campaign, and advocated to achieve these goals through widespread use of strong cryptography and other privacy-enhancing technologies. The 1990s and 2000s saw early concepts of anonymous peer-to-peer communication protocols, some of which, such as Tor and BitTorrent ended up being widely adopted among cyber communities, and are still used today. Some core advances behind blockchain technology also occurred during this period, including the introduction of a computationally practical solution for time-stamping digital documents and the development of technology to more efficiently regroup multiple documents into one block.

It was not until after the publication of Satoshi Nakamoto's whitepaper in 2008 that the world saw the first operational application of blockchain technology. The years 2008-2013 were marked by the emergence of Bitcoin, the first cryptocurrency allowing peer-to-peer financial transactions without the need of any Central Bank or third-party intervention. It was also an era where economies started to shift, slowly but gradually, from paper currency to digital currency.

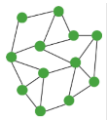
In 2013, Ethereum was born with added functionalities to go beyond the limitations of Bitcoin, such as the ability to support smart contracts[7] and provide a platform for developing decentralised applications[8] (DApps). This turned out to be a pivotal moment in the history of blockchain developments and spurred a large number of cryptocurrencies or blockchain projects built on the Ethereum platform. From 2015, other second-generation blockchain platforms, including Tezos, EOS, IOT, Monero, Zcash, Lightning Network, to name a few, have popped up to address challenges of scalability and security associated with early blockchain applications.

Today, four archetypes of blockchain architecture can be distinguished, classified by access to transaction validation (validate vs commit) and access to participation in the transactions (read vs write) (Allessie *et al*., 2019). Table 2.1 provides an overview with visualisations. The fundamental difference between permissionless and permissioned chains is that the former relies on **economic incentive** (*e.g.* cryptocurrency, tokenomics) to encourage honest behaviour, since the identity of those validating transactions is typically anonymous; whereas in the latter, the identity of the validators is known, hence, their desire to **protect their reputation** is what keeps them acting with integrity.

[7] These are small computer programmes that automatically execute all or parts of a pre-established agreement when conditions get fulfilled, and are stored on a blockchain-based platform.

[8] DApp runs on decentralised nodes of the network, different from a traditional app that runs on centralised servers.

Table 2.1. Four types of blockchain architecture

TYPE	DESCRIPTION	EXAMPLES	VISUALISATION
Public permissionless blockchains	Everyone can participate in the consensus mechanism, and everyone with access to internet can take part in and see full transaction log	Bitcoin, Litecoin, Ethereum, Tezos, Monero, Zcash	
Public permissioned blockchains	Everyone with access to internet can transact and see the transaction log, but only a restricted number of nodes can take part in consensus mechanism	Ripple, private versions of Ethereum	
Private permissionless blockchains	Only pre-authorised nodes can transact and view the transaction log, but the consensus mechanism is open to anyone	(Partially) Exonum	
Private permissioned blockchains	Only the pre-authorised nodes can transact and view the transaction log, and the architect or owner of the blockchain system reserves the right to determine who can access the system and take part in the consensus mechanism	Rubix, Hyperledger	

Notes: Green dots represent validating nodes, i.e. they can participate in the consensus mechanism and validate transactions; blue dots denote participants that are not validators; red ring indicates that only the nodes within the ring can see the transaction log; visualisations without a red ring mean everyone with internet access can see the transaction log.
Source: Allessie et al. (2019).

Relevance for the public sector

Blockchain's features of security, immutability and disintermediation are relevant to many functions of government and public administrations. There would be a case to use blockchain if there is a strong desire to ensure integrity of the data record (*e.g.* in case of electronic voting, public tender, citizen records) or eliminate dependency upon a third-party organisation which may not be trustworthy.

While the most radical innovations are likely to come from public permissionless blockchain networks, whereby everyone can see, commit and validate transactions, companies and governments worldwide have started adopting the technology internally as a way of saving cost, enhancing operational efficiency and/or strengthening government accountability and transparency. Many ongoing experiments are built on permissioned chains, which may seem most applicable for the public sector as they allow control to be retained over who can record new transactions, all while enhancing accountability through identity management and transactional transparency.

This also implies that less computationally intensive consensus protocols (such as Proof of Authority or Round robin models) can be applied to validate transactions – with much higher throughput and instantaneous finality, in case where a large number of parallel transactions need to be processed simultaneously. Proof of Authority model can also be more easily adapted than other models to represent the complexity and multi-stakeholder nature of government approval and decision-making processes (Box 2.2).

Box 2.2. Proof of Authority protocol for the public sector

Proof of Authority provides the ability to validate and publish new blocks to the Blockchain for authorised users, called validators. Unlike consensus models like Proof of Work and Proof of Stake, a user's identity must be known and verified. This is critical, as identity is the sole verification of a user's authority to add new blocks to the chain. When compared with Proof of Work, Proof of Authority is a much faster model for processing new blocks, as there is no need for lengthy and resource intensive computer processing.

The logic with this model is, "Individuals whose identity (and reputation by extension) is at stake for the securing of a network are incentivised to preserve the network" (POA Network, 2017). This consensus model may seem the most familiar to users who have experience working with databases in which only specific authorised users may edit or add data to a database. Thus, it may be the most applicable for many applications of Blockchain technologies in the public sector, as it can be adapted to represent the complexity of government review and decision-making processes (Marchionni, 2017).

To adapt the PoA model to a government ecosystem an extension must be defined. A new consensus mechanism called Distributed Proof of Authority (D-PoA) has been proposed where the Authority is not anymore applied overall but, as the chain itself, is distributed and flexibly adapted to the various authoritative areas constituting the government ecosystem.

D-PoA extends PoA through the following concepts:

1. Nodes must be 'grouped' in 'Areas of Authority' (AoA) where all nodes within one area can only mine blocks and run contracts related to that area (e.g. Health Area of Authority)
2. Nodes within an area of authority can be added with a process involving only the nodes already authoritative for that area.
3. Nodes within their own area of Authority can sign any number of blocks belonging to that area of authority.
4. One node can belong to multiple Areas of Authority
5. There is one Central Master Node acting as Node Management Process Supervisor

Naturally, such extension requires a complex implementation of the consensus mechanism that implies extensive development of the protocol with clear advantages from a governance point of view, but also with some disadvantages linked to its complexity.

3. Major trends in AI and blockchain technology adoption in public sector

The digital transformation of governments has progressed through three phases (OECD, 2019b):

- ***Analogue government***: closed operations and internal focus, analogue procedures;
- ***E-government***: digitisation of existing government processes and online delivery of public services through the use of information and communication technologies (ICTs), particularly the Internet;
- ***Digital government***: the use of digital technologies and data (including big data) to transform the design and implementation process of public policies and services in order to achieve more open and citizen-driven approaches.

Drawing on insights collected through a questionnaire, this section illustrates recent trends in the adoption of AI and blockchain technologies in the public sectors of the 20 Thematic Group (TG) countries. Specifically, it: reviews the presence of national strategies and main actors tasked with advancing the digital government agenda (section 3.1); gauges the level of government support and classify the roles it plays for encouraging public sector uptake of these technologies (section 3.2); and, maps the main areas of public sector adoption (section 3.3).

The OECD AI Recommendation, adopted in May 2019, is the first international standards agreed by governments for the responsible stewardship of trustworthy AI. Beyond OECD Members, other countries including Argentina, Brazil, Colombia, Costa Rica, Peru and Romania have adhered to the AI Principles. In June 2019, the G20 adopted human-centred AI Principles that draw from the OECD AI Principles, as well as the Ministerial Statement on Trade and Digital Economy. The OECD Principles on AI include concrete recommendations for public policy and strategy.

Box 3.1. The OECD AI Recommendation

The Recommendation identifies five complementary values-based principles for the responsible stewardship of trustworthy AI:

- AI should benefit people and the planet by driving inclusive growth, sustainable development and well-being.
- AI systems should be designed in a way that respects the rule of law, human rights, democratic values and diversity, and they should include appropriate safeguards – for example, enabling human intervention where necessary – to ensure a fair and just society.
- There should be transparency and responsible disclosure around AI systems to ensure that people understand AI-based outcomes and can challenge them.
- AI systems must function in a robust, secure and safe way throughout their life cycles and potential risks should be continually assessed and managed.

- Organisations and individuals developing, deploying or operating AI systems should be held accountable for their proper functioning in line with the above principles.

Consistent with these value-based principles, it provides five recommendations to governments:

- Facilitate public and private investment in research and development to spur innovation in trustworthy AI.
- Foster accessible AI ecosystems with digital infrastructure and technologies and mechanisms to share data and knowledge.
- Ensure a policy environment that will open the way to deployment of trustworthy AI systems.
- Empower people with the skills for AI and support workers for a fair transition.
- Co-operate across borders and sectors to progress on responsible stewardship of trustworthy AI.

According to the OECD Recommendation,AI should contribute to inclusive and sustainable growth and well-being. Second, it should be used in ways that respect human-centred values and fairness. Third, the use of AI and how its systems operate should be transparent. Fourth, AI systems should be robust and safe. Fifth, there should be accountability for the results of AI predictions and the ensuing decisions. Such measures are viewed as critical for high-stakes predictions. They are also important in business recommendations or for less impactful uses of AI.

National policies are needed to promote trustworthy AI systems. Such policies can spur beneficial and fair outcomes for people and for the planet, especially in promising areas underserved by market-driven investments. The creation of an enabling policy environment for trustworthy AI includes, among other things, facilitating public and private investment in AI research and development and equipping people with the skills necessary to succeed as work evolves.

3.1. A diverse approach in building ET national strategies and governing bodies in the public sector

All 20 TG countries have announced national strategies and policy initiatives to advance the digital transformation of their economies and societies, including that of the digital government agenda. The majority of these strategies and initiatives dedicate a section to the development of data-driven and citizen-centred government. A few, including Canada, Chile, Estonia, Italy, Netherlands, New Zealand, the UK and Uruguay have devised or are currently developing targeted plans for moving from e-government towards digital government.

These strategic documents commonly aim to achieve greater **efficiency**, transparency and accountability in the way administrative services are delivered; enhance **interoperability** of the state information system to break silos and bolster efficiency in work processes; and increase the **use of data and analytics** in policy and decision-making so as to better anticipate and respond to the changing needs of citizens and businesses. While there is generally continued emphasis on paperless administration, open data and government, the

more digitally advanced countries, such as Estonia, have set up ambitious (sometimes numerical) targets on aspects including: quality and user satisfaction of public digital services; uptake of emerging technologies in public sector; security and resilience of the state information infrastructure; and the level of digital knowledge and skills among public sector employees.

Four pillars of actions are typically mentioned to achieve these goals:

- **Government as a platform to foster more user-driven service design and delivery**: continue pursuing higher integration and interoperability of systems, expand access to and use of common key enablers (e.g. digital identity) or harmonise public sector data to streamline various user-facing procedures and break down organisational silos for more collaborative governments.
- **Data-driven public sector and open data:** continue to promote public sector information disclosure, strengthen personal data protection, and enable the participation of citizens and non-governmental stakeholders in decision-making process;
- **Digital capability**: strengthen digital literacy (*i.e.* the use of data, analytics and IT tools) and talent attraction within the public sector, through training, reskilling, lifelong education and rethinking job profiling;
- **Technology and infrastructure**: develop trusted and secure connectivity infrastructure (*e.g.* broadband and 5G coverage) that underpins all activities of the digital economy and digital government, raise cyber security standards and implement IT modernisation including through innovative procurement practices and encouraging open source.

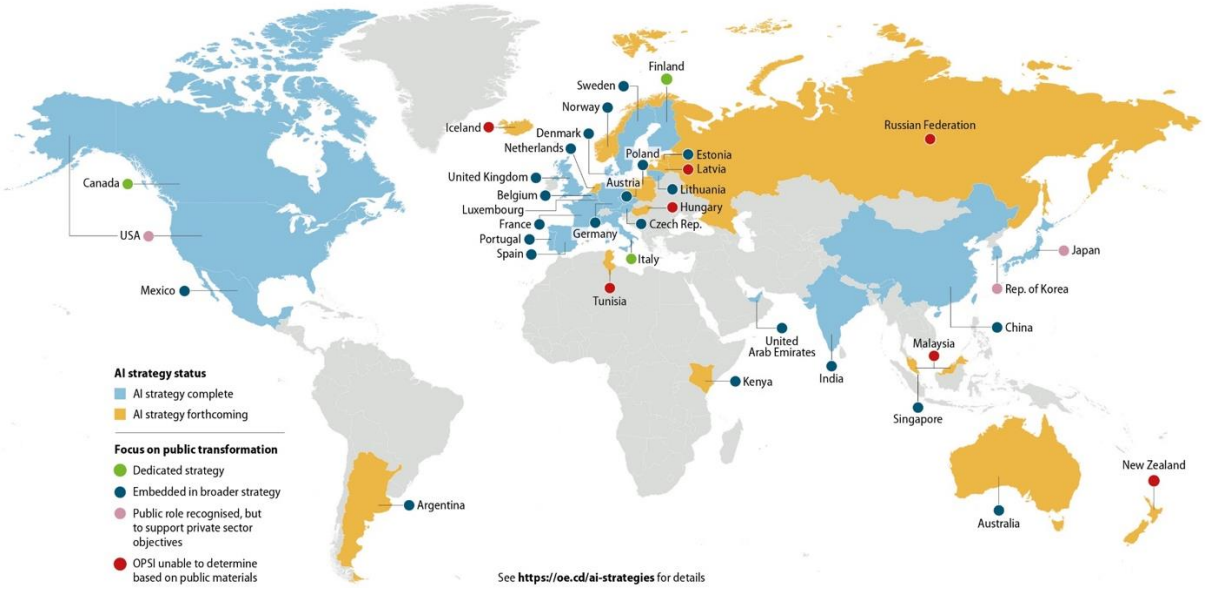
References to specific types of technologies are not systematically included, but when they do, these have shifted from cloud-based solutions, social media, web or mobile applications that dominated the strategies developed during the first half of the 2010s (OECD 2003, 2005, 2009, 2011), to advanced analytics, AI, blockchain and Internet of Things in more recently drafted documents.

Additionally, most of the TG countries have devised national strategies specific to the development of AI technology, many of which include a focus on promoting its introduction in public sector, with the aim of making public service delivery more efficient, convenient and inclusive. On the other hand, none of the TG countries, with the exception of Italy, have so far introduced overarching documents on blockchain technology, despite a growing number of government-led use case pilots, working groups and policy papers. The Italian Simplification decree of 2019 introduces the regulatory definition of technologies based on distributed registers (blockchain) and smart contracts. The decree also provides that the storage of an electronic document through the use of technologies based on distributed registers produces the legal effects of electronic time validation.

As key actors are concerned, the majority of the TG countries have created, or assigned responsibility to, a specific entity within the central administration for managing the overall coordination and implementation of the digital government agenda. Typically, these entities are either permanent structures coordinating actions among different arms of the administration, or *ad hoc* teams dedicated to fostering the uptake of emerging technologies across the public sector. Figure X.X gives a picture of the current status of AI strategies and the extend to witch they include public sector transformation table 3.1 summarises

these strategies and key actors in the 20 TG countries. This section does not assess the achievement of the goals of national initiatives, or the success of these approaches.

Figure 3.1. AI strategy status



Source: OPSI analysis of national strategies (see https://oecd-opsi.org/projects/ai/strategies). OECD (forthcoming), *State of the Art on Emerging Technologies in the Public Sector*.

National strategies have taken very diverse approaches and the governance of ET in the public sector is very dissimilar form country to country undermining somehow the possibility for future interstate cooperation in this field.

Table 3.1. Overview of national strategies and main actors in digital government in TG countries

COUNTRY	NATIONAL DIGITAL STRATEGY	AI STRATEGY	BLOCKCHAIN STRATEGY	MAIN ACTORS IN DIGITAL GOVERNMENT AND MANDATES
Argentina	Digital Agenda 2030 (2018)	National AI Strategy (finalisation stage)		Planning and Follow-Up Council will be charged to define guidelines, objectives and priorities for implementing the national digital strategy
Australia	Digital Transformation Strategy(2018)	National AI Ethics Framework and Artificial Intelligence Roadmap (drafting stage)	National Blockchain Roadmap (drafting stage)	Digital Transformation Agency encompassing representatives from different agencies is at the forefront of evaluating potential use of ET and scaling adoption of digital interfaces across government
Canada	Information Technology Strategic Plan 2016-20 and subsequent iterations, notablyDigital Operations Strategic Plan 2018-22 (2018)	Pan-Canadian AI Strategy (drafting stage) Treasury Board White Paper "Responsible AI in the Government of Canada" (specific for public sector use)	Canadian Digital Service co-creates digital services with departments. Treasury Board assists federal institutions by providing recommendations on how to implement AI systems	Canadian Digital Service co-creates digital services with departments. Treasury Board assists federal institutions by providing recommendations on how to implement AI systems
Chile	Digital Agenda for Chile 2013-20(2013) Digital Transformation Strategy of the State (drafting stage)	Data and AI Policy (drafting stage)	Working Groups in 6 areas but no national overarching strategy on blockchain	"Future Economy" workstream within the Ministry of Economy leads policy discussions on ET, with the participation of the Digital Government Division of the Presidency's General Secretariat and Ministries of Health, Energy and Finance
Colombia	Online Government Strategy (e-Government)			Excellence Centre of IoT and Advanced Analytics Digital Government Innovation Centre (or Innovation Centre for Digital Public Innovation) explores solutions for the trough ET ICT Ministry involved in supporting the use of ET in both public and private sectors
Estonia	Digital Agenda 2020 (2013) and the 2018 update	National AI Strategy (drafting stage) Kratt Report (2019)		Government CIO office targets and funds ET projects A national expert group has been tasked to come up with a national AI strategy and regulatory proposals by spring 2019
Finland	Digitalisation in the Government Programme (2015, 2019) and 2018-19 Action Plan, Information Policy report 2019	National AI Strategy papers "Finland's Age of Artificial Intelligence" and "Leading the Way into the Age of Artificial Intelligence"		There is no centralized actor for the implementation of emerging technologies. Ministry of Finance would be steering the general utilization of AI in public sector and the agency for digital services will have a role for quidance of AI and for implementation of general purpose solutions. Sector specific ministries have also significant role in their field of responsibility.

Italy	Strategy for Digital Growth (2015) Three-Year Plan for ICT in the Public Administration 2019-21 (2019)	National AI Strategy (2019) AgID Whitepaper "AI at the service of citizens" (2018)	National Strategy on Blockchain (drafting stage)	Agency for Digital Italy (AgID) manages Digital Agenda implementation; contributes to the diffusion of ICTs; and collaborates with Ministries of Economic Development and Finance on piloting services and products for ameliorating digital service delivery. A new Department for Security and Digital Innovation will start operating in January 2020 to boost digital innovation in the public sector. Artificial Intelligence and Blockchain Tasks Forces (set up by Ministry of Economic Development) study the opportunities offered by AI and blockchain to improve public services, simplify the lives of citizens and business.
Korea	Plan for the Fourth Industrial Revolution (I-Korea 4.0) (2017)	AI R&D Strategy Strategy for Data Industry Promotion		Presidential Committee on the Fourth Industrial Revolution plays a central role in spreading hyper-intelligent, hyper-connected technologies (AI, IoT and 5G). It consists of 25 members, including the Science Advisor to the President, private sector experts and ministers. It deliberates and mediates on action plans and policies adopted by individual ministries; is expected to secure R&D progress for fundamental technologies; and nurtures new industries and services
Latvia	Data Driven Nation Memorandum	AINED report.		The , AINED report has formulated a first draft for a Dutch National AI strategy, a setup that will provide a concrete action plan to make AI a national priority.
Mexico	National Digital Strategy (2013)			Office of the President (through the Coordination of National Digital Strategy), Ministry of Public Administration (through its Digital Government Unit) and Inter-secretarial Commission for the Development of Digital Government and its Sub-Commissions. They work closely with Ministries of Finance, Communications and Transport and with National Governor's Commission DataLab – to promote the use of data science, AI related technologies, and Open Data GobLab - an internal unit of the Coordination of National Digital Strategy in charge of providing data-based capacities and knowledge for the development and evaluation of public policies in Mexico, as well as the creation of capacities and awareness in the public of the value of data GobLab - an internal unit of the Coordination of National Digital Strategy in charge of providing data-based capacities and knowledge for the development and evaluation of public policies in Mexico, as well as the creation of capacities and awareness in the public of the value of data

Netherlands	Dutch Digitalisation Strategy (2018) Digital Government Agenda (2018)	Strategic Action Plan for AI (drafting stage)	No official central body coordinating sector-specific actions of various Ministries: Economic Affairs and Climate Policy (digital single market), Interior and Kingdom Relations (e-Government, civil rights), Justice and Security (cybersecurity), Infrastructure and Water (mobility), Health, Welfare and Sport (e-health) and Education, Culture and Science (education, science)
New Zealand	Government ICT Strategy (2015) Digital Government Strategy (drafting stage)		Government Chief Digital Officer tasked with fostering collaboration and accelerating digital transformation across government agencies, through actions such as executive training and cross-agency initiatives
Panama	Agenda Digital Panama 4.0 (2014)		National Authority for Government Innovation (AIG) plans and coordinates the role of technology within government; oversees national strategic policies and produces guidelines in partnership with several different institutions
Portugal	ICT Strategy 2020 (2017)	National Strategy for AI (drafting stage	Council for ICTs in Public Administration, a technical committee under aegis of Agency for Administrative Modernisation (AMA), is in charge of promoting establishment of a Digital Skills Centre for the Public Administration (named ticAPP)
Slovenia	Digital Slovenia 2020 (2016)		Ministries of Public Administration; Education, Science and Sport; and Economic Development and Technology
Spain	Digital Agenda for Spain (2013)	National Strategy for AI (drafting stage`)	Ministry of Industry, Energy and Tourism
Sweden	Strategy for Sustainable Digital Transformation in Sweden (2017)	AI in Swedish Business and Society	A digitalisation council and office within the Swedish Post and Telecom Authority support the implementation of the national digital strategy Innovation Council advises the government on further improving its innovation policy, focusing on key challenge areas such as digitalisation, life sciences, environment and climate
UK	UK Digital Strategy (2017) Government Transformation Strategy 2017-20 (2017) Government Technology Innovation Strategy (2019) AI Guide (2019) with the Office for AI (a DCMS/BEIS joint unit) Technology Innovation in Government Survey (2018)	AI Sector Deal	The Government Digital Service (GDS) within the Cabinet Office leads the digital transformation agenda by setting and enforcing standards for digital service design and delivery across policy areas. GDS supports the increased use of ETs across the public sector through vehicles such as the £20M GovTech Catalyst fund. This creates a pathway to facilitate the adoption of ET solutions developed by the private sector to solve public sector challenges.

		The Office for AI is a joint BEIS-DCMS unit responsible for overseeing implementation of the UK's AI strategy and the AI and Data Grand Challenge. Its mission is to drive responsible and innovative uptake of AI technologies for the benefit of everyone in the UK. By engaging organisations, fostering growth and delivering recommendations around data, skills and public and private sector adoption.		
Uruguay	Agenda Uruguay Digital 2020 (2016) Digital Government Strategy 2020 (2018)			Department on Emerging Technologies, established specifically within the Agency for e-Government and Information and Knowledge Society at the President's Office leads implementation of the Digital Government Plan
European Union	Data Package	Coordinated Action Plan on AI Development in EU18 Ethics Guidelines for Trustworthy AI AI@EC	EU Blockchain Observatory	High Level Group on AI sets guidelines and coordinates action plans across EU Member States, along with European AI Alliance European Blockchain Partnership promotes cooperation and knowledge sharing on technical and regulatory issues, in preparation for launching EU-wide blockchain applications across the Digital Single Market and the European Blockchain Services Infrastructure for deploying first set of cross-border digital public services

Source: Participating countries in the Thematic Group on Emerging Technologies.

Notes

1. The Argentinian Secretary of Government of Science and Technology launched within the Digital Agenda the "National Plan of Artificial Intelligence". The plan seeks to position the country as a regional leader in the field, and maximise the generation and use of knowledge with the ultimate goal of improving the competitiveness of the private sector and modernising the management of the State to provide better services to citizens. It includes participation of all relevant actors: academia, civil society and private sector.

2. Australia does not have a specific AI strategy, but its "Digital Transformation Strategy" includes emerging technologies, such as AI. To make government smarter through AI and data by 2025, its strategic objectives include the use of data analytics to shape and form all public policies. Agencies are expected to use and reuse public sector data through data integration and a federated approach to data and all services will be personalised and enriched using AI and advanced analytics.

3. Canada has drafted a "Pan-Canadian Artificial Intelligence Strategy" to retain and attract top academic talent, and increase the number of postgraduate trainees and researchers studying AI and deep learning. The Strategy aims to promote collaboration among Canada's main centres of expertise in Montréal, Toronto-Waterloo and Edmonton, and position Canada as a world-leading destination for companies seeking to innovate through the application of AI. It is important to note that the Strategy focuses on developing research and development capacity more broadly across the economy and society, not public sector capacity specifically. Along with that, Canada has an AI strategy specifically for public sector: the Treasury Board has released a white paper which examines the policy, technical, ethical and legal considerations around the use of this technology within the Government of the Canada (Karlin, 2018[12]). Its primary objective is to assist federal institutions by providing recommendations on how to implement these systems.

4. The Chilean Ministry of Economy set up public-private working tables in 2018 to explore opportunities for the use blockchain technology in six areas: Digital Identity, Commerce, Financial Services, Registration Systems, Energy and Health. The objective was to generate a technical document, to review the context of each area, identify international success experiences and explore possible blockchain projects to develop in Chile (Carrión, 2017[13]).

5. In May 2017, Finland's Ministry of Economic Affairs and Employment created an Artificial Intelligence Programme and a Steering Group to ensure its guidance. The group leveraged a broad network of experts to explore key questions about how best to support the public and private sectors in producing AI-based innovation, how to position government data as resources for economic development, how AI will affect society and what the public sector should do to move Finland towards an AI-driven future. As a consequence of this work, the Steering Group issued two key reports that set forth Finland's approach to AI. Finland's Age of Artificial Intelligence117 (December 2017) and Leading the Way into the Age of Artificial Intelligence (June 2019) collectively lay out 11 key actions covering all sectors to help Finland achieve its ambitious goal. For the public sector, the Age of AI report calls for the government to establish Aurora, a network of different smart services and applications to "allow the public administration to better anticipate and provide resources for future service needs" and to allow citizens to access high-quality 24/7 digital services. Since the initial concept for Aurora was released, it has been expanded significantly into the AuroraAI National AI Programme. AuroraAI seeks to provide a holistic set of personalised AI-driven services for citizens and businesses in a way that is human-centric and works towards their wellbeing as its ultimate goal.

6. The Italian "Artificial Intelligence Task Force" released a white paper to analyse the impact of AI on our society and, specifically, how these technologies can be used by the public sector to improve services for citizens and businesses (AGID, 2018[14]). The White Paper also includes recommendations on how to use or introduce AI solution in the public sector. In 2019 the Ministry of Economic Development launched the National Strategy on AI with a focus on the use of AI at national level, with a clear view on the application of AI to the Sustainable Development Goals.

7. The Latvian "Data Driven Nation Memorandum (DDN)" focused on data accessibility, cloud computing, the development of the open data portal, the establishment of public-private partnerships for the development of new data-driven products and for society's inclusion in decision making process.

8. Mexico does not have an official national strategy on AI, although a white paper entitled "Towards an AI Strategy in Mexico: Harnessing the AI Revolution" was prepared in January 2018 by the Government of Mexico, together with Oxford Insights, C-Minds, the Mexican Society for Artificial

Intelligence and the Tec de Monterrey, to provide recommendations for the development of Mexico's AI strategy and to promote the development and use of AI in all sectors of society.

9. Based on its digital strategy, the Netherlands plans to develop agendas for specific areas, such as the National Cyber Security Agenda.

10. In New Zealand, the next iteration of the government digital strategy will address emerging technologies along with other aspects of the evolving digital environment. The New Zealand's government has also cosponsored a number of reports on the current state of emerging technologies to provide recommendations for relevant uptake, most notably the AI Forum's "Artificial Intelligence: Shaping a Future New Zealand".

11. The Foundation for Science and Technology (FCT), a public agency under the Portuguese Ministry of Science, Technology and Higher Education, is tasked with preparing the National Strategy for AI.

12. In 2017, the UK government published two other reports related to technology innovation, respectively "Growing the artificial intelligence industry in the UK" and "Delivering better outcomes for citizens: practical steps for unlocking public value". The second report posits that incremental and disruptive innovation should lead to public value creation and efficiencies procuring marginal gains.

13. Uruguay's "Digital Government Strategy 2020" defines the objectives and guidelines that encourage the country's digital transformation. Its structure proposes a holistic vision of Digital Government composed of six areas of actions, each with a set of target objectives and goals. "Intensive use of data and emerging technologies" is one of the main objectives under the Smart Government area.

    "Tecnologías Emergentes" (ET) is a specific department within Agesic's technology area whose main tasks are:

    - To research, develop and promote the use of innovative and emerging technologies that contribute to the creation of value and facilitate effective management in State organizations

    - Analyze and disseminate methodologies, good practices and innovative IT solutions that enhance the digital transformation of government.

    - Generate proofs of concept on emerging and innovative IT solutions that guide the selection of technologies to be applied in digital transformation projects.

14. In addition to the national strategies, the European Commission (EC) is actively promoting emerging technologies at the EU level. In particular, the EC:

    - Issued "Data Package" in April 2018, an initiative that puts forward a set of measures to increase the availability of data in the EU, with the ultimate goal of building a European data economy;

    - Outlined a European approach in April 2018 to boost investment, set ethical guidelines in AI and establish a High-Level Group on AI along with a European AI alliance. In December 2018, the EC and Member States published the "Coordinated action plan on the development of AI in the EU 18" to promote the development of AI in Europe. The action plan recognises: 1) the need for all European countries to work together to make the most of the opportunities offered by AI and become a world leader in this crucial technology for the future; 2) the prominent role of ethical matters in this area; 3) the required collaboration between the European Commission and Member States to address the new challenges brought by AI. The action plan also outlines measures of AI for the public sector, such as joint procurement and translations. As regards AI and ethics, the AI HLEG released the "Ethics guidelines for trustworthy AI" in April 2019;

    - Launched an EU blockchain observatory in February 2018 to highlight key developments of this technology, promote European actors and reinforce European engagement with multiple stakeholders involved in blockchain activities. Further, the European Blockchain Partnership (EBP) was established in June 2018, as a vehicle for promoting cooperation amongst EU member states to exchange experience and expertise and prepare for the launch of EU-wide blockchain applications across the Digital Single Market, for the benefit of the public and private sectors. In 2019, the EC in cooperation with the EBP and other stakeholders will initiate the creation of European Blockchain Services Infrastructure (EBSI), to deploy the first set of cross-border digital public services.

3.2. Growing public support to encourage research and application

Both AI and blockchain are general purpose technologies with the potential to impact a wide range of economic and social activities. Governments can play multiple roles to strengthen national research capacity and help translate technological progress into public and private sector applications. This section reviews the size and forms of government support for encouraging research and application of AI and blockchain in public sector among the TG countries. It has identified three roles that governments can play simultaneously: as a financier or direct investor, as a smart buyer and co-developer, and as a regulator or rules maker.

Government as a financier or direct investor

Governments can provide funding to support the development and adoption of emerging technologies, and by doing so, can prioritise areas of public benefit that would be under-served by the private sector. While there is no systematic statistical review of the size and forms of government funding for public sector adoption of AI and blockchain, a number of funding schemes related to call for projects or pilot tenders have been identified. Table 3.2 summarises these programmes and provides a tentative and partial indication of the scope of public support in TG countries. The figures presented are non-exhaustive estimates, are not directly comparable across countries, and generally include support for pre-commercial R&D projects whose outcomes may apply to the economy at large and not the public sector alone.

Table 3.2. Overview of government support for public sector adoption of emerging technologies

COUNTRY	BUDGET & TIMEFRAME	FUNDING SOURCES	FORMS OF ALLOCATION	SUPPORTED TECHNOLOGIES & PURPOSES
Australia	$3.27 million (€2.04 mln) over next year	Government	Direct project financing	AU$25 million for a Cooperative Research Centres program to support joint private and public research on AI and ML. AU$1.4 million for AI/ML PhD scholarships. AU$25 million to support quantum computing. AU$140 million to upgrade High Performance computing infrastructure at Pawesey Supercomputing centre and the National Computational Infrastructure. AU$.35 to develop blockchain standards.
Canada	$125 mln (€82 mln)	Pan-Canadian AI Strategy		AI funding will be governed by the non-governmental Canadian Institute for Advanced Research
Finland	€10 mln	Ministry of Finance		A targeted financing option to public sector organisations for developing advanced AI and robotics solutions
Italy	€1.15 billion	Ministries of Education, Economy, EU & venture funds	PPP, public procurement, project financing	€100 mln distributed annually by Ministry of University, Research and Education, through pre-commercial or PPP procurement, to foster R&D and innovation €45 mln foreseen by the Italian Operational Programme for AI and distributed ledger technology R&D €1 billion venture capital fund targeting R&D in businesses and academia

Korea	KRW 12.2 trillion (€9.2 bln) by 2022	Government & venture fund		KRW 2.2 trillion (€1.66 bln) in R&D of intelligent technologies KRW 10 trillion (€7.54 bln) through the Innovative Venture Fund
Portugal	€10 mln over 3 years	Foundation for Science and Technology	Call for tenders	The funding aims to spur the use of data and AI in the public sector. The first call for tender granted €3.8 mln to 15 research projects, 4 of which focused on AI 4 other AI research projects beyond the above scheme were granted €0.5 mln to predict the risk of long-term unemployment and detect abnormal patterns of antibiotic prescription. More than 44 projects were submitted and approved under SAMA2020 program. (Call n.º 01/SAMA2020/2019)
Slovenia	€25-50 mln	Government		
Sweden	SEK 1 billion (€97 mln) over 10 years	National Innovation Council, Vinnova	Direct project financing	Funding for AI projects
UK	£20 mln (€23 mln)	GovTech Catalyst		AI Sector Deal £0.95bn Connected and Autonomous Vehicles £250 mln National Quantum Technologies Programme £270 mln National Artificial Intelligence Lab (Health) £250 mln The UK government has committed that R&D expenditure will reach 2.4% of GDP by 2027
EU	€9.2 billion over 2021-27	Digital Europe Programme		€2.7 bln for supercomputers, €2.5 bln for AI €2 bln for cyber security and trust, €700 mln for digital skills €1.3 bln for society-wide use of digital technologies

Source: Author's elaboration based on responses from Thematic Group (TG) countries.

In **Italy** the National Innovation Fund (FNI), established as a public venture capital by the Ministry of Economic Development, has a starting budget, foreseen in the 2019 Budget Law, of about 1 billion euro, aims to bring together and multiply public and private resources dedicated to the strategic theme of innovation.

An interesting example of Portugal is the annual competitive call for projects organised by the Portuguese Foundation for Science and Technology under the National Digital Competency Initiative, "Portugal INCoDe.2030". The Foundation has rolled out a "Programme in Data Science and AI in Public Administration" through open tenders to support R&D projects aimed at improving the analysis of large amounts of data available in the public administration, in order to improve the provision of public services and assist decision-making processes with better evidence.

In Uruguay organised in 2019 the second Artificial Intelligence (AI) event: IA-ckaton 2019, "Artificial Intelligence to improve public services".

The objective of the IA-ckaton is to generate, define and develop innovative projects that improve State services supported by this technology. In addition to promoting experimentation and the development of the best projects in IA, the activity seeks to

encourage entrepreneurship and collaborative work in an environment of healthy competition.

In this edition, the activity is supported by the Electronic Government Network of Latin America and the Caribbean (Red Gealc), which brings together the Digital Government authorities of the countries of the region and aims to support Digital Government policies that place citizens and, in particular, the most vulnerable populations at the center of their work.

Government as a smart buyer and co-developer

With funding schemes established, the next step for governments to undertake is to identify viable projects and meaningful use cases to experiment with. ICT procurement or digital sourcing is an important part of the public sector value chain, supplying goods and services integrated in many parts of the public service delivery.

Governments can act as a **smart buyer** of existing solutions through innovative procurement practices, or as a **co-developer** through public-private partnerships (PPP) and other forms of collaboration to build new or tailored solutions. Governments can drive innovation from the demand side by steering the development of new solutions directly towards its needs, or to better respond to users' needs. An innovative approach is **pre-commercial procurement**. This involves public administrations procuring new services or products that are still at a pre-commercial stage of research and development by sharing the risks and benefits of design, prototyping and testing with private sector suppliers.

Based on responses from 22 OECD countries to a 2014 survey on Digital Government Performance, half of the countries surveyed have a strategy in place specifically targeting ICT procurement, whether it exists within selected line ministries, across the central government or across different levels of government (OECD Dataset on Digital Government Performance). **Risk aversion** is however frequently observed in the procurement practices of digital technologies. Two thirds of the surveyed countries prioritise procuring standardised ICT solutions over tailored business needs, with an equal share of countries preferring to purchase proven technologies rather than exploring untested innovative approaches (OECD Dataset on Digital Government Performance).

Countries are evenly divided on where to draw the balance between achieving economies of scale (hence best value for the public sector) and stimulating innovation when making a digital procurement decision. Many IT projects in government and public services are extremely large, complex and monolithic, and often require partnering with top-tier IT service providers capable of undertaking far-reaching and transformational projects. However, this may encourage rent-seeking behaviour around proprietary software and possibly open the door to public sector dependency on these suppliers and a situation of technological lock-in.

Governments worldwide have started to update procurement and contracting rules to better source innovation to support the digital transformation in the public sector, all while diversifying the sources of suppliers. An emerging good practice has been the introduction of **digital marketplace**, which has the potential to transform how government can work as a single customer and make it simpler, faster and more cost efficient for a wider range of market actors to access industry innovation. Several TG countries, such as Australia, Estonia, New Zealand, the UK, have introduced a digital marketplace to allow more flexible and agile procurement processes and reduce agency silos.

An important objective of these marketplaces has been to reduce barriers for smaller and potentially local businesses by giving them a leg up when competing for lucrative public sector contracts, thereby levelling a playing field that has traditionally been dominated by large, top tier international suppliers. The experience of the **UK** has shown early signs of success. Since its launch in 2014, the UK Digital Marketplace has seen over £4.3 billion worth of contracts pass through it, with just under half of that going to small and medium-sized enterprises (OECD, 2018). This, compared to 2009, when fewer than twenty companies retained 80% of the UK's £16 billion of annual IT spending, is a first step towards supporting broader-based growth of the digital sector, particularly for start-ups and scale-ups. In addition to the Digital Marketplace, in 2019 the UK government launched SPARK , a new marketplace for innovation that provides a smarter way for public sector customers to access the very latest technologies.

There are also expected benefits for the public sector, notwithstanding the perception of being open for business and competition and a start of cultural and behavioural change towards more experimentation and calculated risk-taking, both of which are essential qualities and mind-sets for driving the adoption of emerging technologies in the public sector.

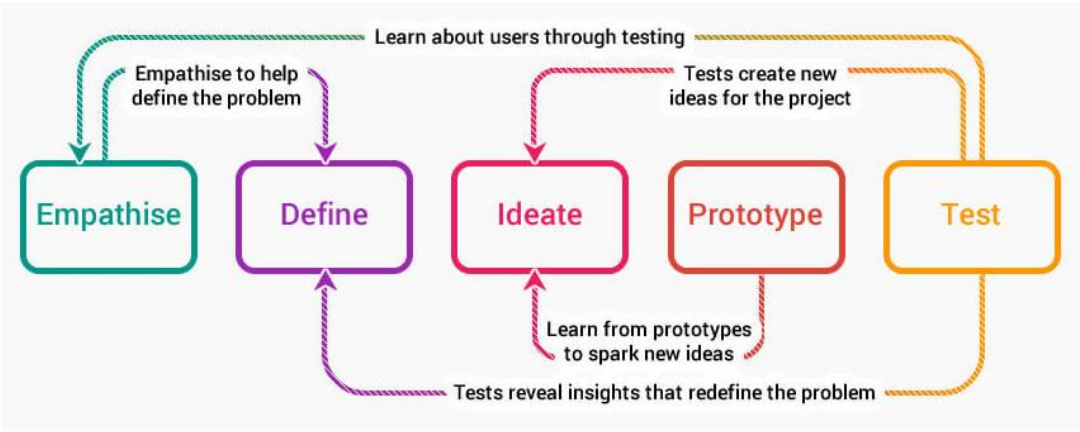
Italy has launched the innovative procurement portal to favor the emergence, qualification and aggregation of innovation needs of public administrations; contribute to the dissemination of knowledge, by the administrations, of the methods and tools to carry out projects and procurement of innovation; to involve the market as widely as possible, channeling it towards the knowledge of innovative public demand and stimulating the proposition of the best possible solutions in a logic of open innovation; and to favor the meeting between the demand and the offer of innovative solutions, encouraging an effective collaboration between PA, companies and research bodies, in line with the provisions of the national Digital Agenda.

Meanwhile, governments are playing a more proactive role in building digital solutions alongside academia and industry. At times, governments have also operated in **"start-up" mode**, where experiments with new technologies are deployed, evaluated and modified, and then scaled up or down, or abandoned quickly. A growing number of public sector applications of emerging technologies are promoted via the implementation of Proof of Concept (PoC) that aim at confirming the feasibility of some idea before prototyping potential solutions. For instance, the European Commission launched a few PoCs over the course of 2018, targeting different thematic areas ranging from semantic analysis, detection and identification of document insights, image recognition to development of chatbots, fraud detection, macro socio-environmental-economic scenarios. **Italy** has launched two platforms for design (https://designers.italia.it/) and development (https://developers.italia.it/) of public digital services. Designers Italia is the point of reference for the design of the Public Administration: guides, work tools and a forum to foster collaboration between designers and strengthen the role of design in the development of public services. Developers Italia is a collaborative community open to everyone's contribution: public administrators, developers, technicians and ordinary citizens. It was created to create a more open and more evolved digital Italy. Governments around the world are also hosting hackathons to source innovative ideas for solving pain points in public services delivery or policy formulation.

Over the past few years, the popularisation of a **design thinking** approach in the public sector has further boosted governments' ability to think outside the box when delivering public value using new technologies. Originally developed and used by designers,

architects and the private sector, design thinking is a creative problem-solving process that puts the user at the centre of attention (UNDP, 2014). It results from an iterative process of listening to end-users and engaging them in co-shaping decisions (professional empathy and co-creation); considering the multiple causes, dimensions and size of the problems at hand (scaling); and experimenting with initial ideas to gain first-hand feedback (ideation, prototyping and testing) (Figure 3.1). Such a non-linear approach stimulates creative thinking within the decision-making process and has been increasingly applied to concrete public service delivery projects.

Figure 3.2. Design thinking: A non-linear approach



Source of visual: interaction-design.org

Government as a regulator or rules maker

Accelerated innovation cycles of the emerging technologies call for rethinking the types of policy and regulatory instruments used and their implementation. Digitalisation challenges the rationale for traditional approaches to the design, enforcement and governance of regulation. As both an enabler and a user of emerging digital technologies, governments are facing the challenge of how to regulate them to maximise their innovative potential while minimising the risks for end users, in a number of areas such as privacy, security, safety, cross-border data flows and employment. The diversity of challenges raised by digital transformation will require a holistic, whole-of-government approach to ensure coherence across policy objectives, as well as regulatory co-operation between countries to address transboundary challenges of digitalisation (OECD, 2019d).

Governments can use regulatory sandboxes, innovation centres and policy labs to provide controlled environments in which emerging technologies can be tested. For instance, Argentina is in the process of establishing a national AI Innovation Hub to implement projects in various thematic groups, each of which will be governed by a steering group charged with defining goals and metrics to measure progress.

Approaches to ensure rapid and agile policy responsiveness include policy experiments that operate in "start-up mode" whereby experiments are deployed, evaluated and modified, and then scaled up or down, or abandoned quickly (OECD, 2018). Using digital tools to design policy and monitor targets is another option to spur faster and more effective decision-making (OECD, 2018). For instance, some governments use "agent-based modelling" to anticipate the impact of policy variants on different types of businesses or use cases (OECD, 2019c). Based on the OECD AI Recommendation, the OECD is currently

developing practical guidance to promote its implementation in countries. This will include concrete guidance for implementing the recommendation on "shaping an enabling policy environment for AI".

3.3. Mapping uptake of AI and blockchain in the public sector

Governments in the 20 TG countries are currently experimenting with and implementing projects aimed at exploiting emerging digital technologies to better meet the needs of public-service users and steward their resources. These projects increasingly centre around the applications of AI technology, and more recently of blockchain to a lesser extent. They fall under four broad areas (Table 3.3):

- Enhancing the quality of citizen-facing welfare services;
- Increasing operational efficiency and security;
- Preserving the environment, natural capital and climate resilience;
- Making data-driven policy decisions for better governance.

This section will highlight a few areas in the public sector that are seeing widespread or rapid uptake of AI and blockchain technologies; illustrate the benefits and purposes of these applications; and present a list of initiatives and concrete examples undertaken by the TG countries.

Table 3.3. Use cases of AI and blockchain across TG countries – A non-exhaustive list

AREAS OF APPLICATION	AI	BLOCKCHAIN
	1. Citizen engagement & welfare services	
1.1. Health & caring	• Deploy nursing robots to attend the elderly and people with disabilities • Overcome dementia with low-cost, high-precision diagnosis • Prevent patients from falling or getting lost • Automate the delivery of eye exam diagnosis • Detect risk of abnormal patterns of antibiotic prescription • Improve cancer screening through use of AI • Improve clinical diagnoses and suggestion of treatments	• Notarise corporate compliancy to worker's health regulations
1.2. Employment & social security	• Predict long-term unemployment risk • Monitor labour obligations compliance • Analyse behaviour of cases attended by the social security oversight body, streamline processing and detect opportunities for improvement • Detect Fraud	• Develop intelligent transactions and use smart contract as employment contract to automatically collect payroll taxes
1.3. Education & schooling		• Notarise study career certificates and provide cross-country attestation
1.4. Immigration	• Identify patterns in immigration and visa irregularities using ML in order to inform the design of fair and effective operating procedures	• Protect refugees' identity in the issuance of payment cards using smart contracts
1.5. Civil rights services	• Prevent duplicates in passport issuance using facial image recognition • Strengthen border control with facial image recognition • Identify fraud in digital identity applications through machine learning • Ameliorate access to justice and the work of public prosecutors • Automatic Law codification using NLP • Respond rapidly to gender based violence detection	• Ensure document authenticity for citizen authentication

1.6. General public & welfare services	• Reduce welfare blind spots using big data to discover socially vulnerable people at all time • Automate the disbursement of annual rights from public funds (e.g. child allowance, subsidy of kindergarten, snack, lunch, state scholarship) • Improve government website navigation experience with virtual assistant (chatbot) and voice-based software • Improve service user experience in call centre applications using speech recognition • Deploy chatbots to speed up the process of issuing licenses.	
2. Operational efficiency & security		
2.1. Transportation	• Build AI-powered supply chain supercluster that brings retail, manufacturing, transportation as well as infrastructure and information communication technology together • Scan pre-load air cargo information to provide a list of air cargo that may need further risk mitigation strategies • Facilitate and fund the growth of the autonomous vehicle sector	
2.2. Food safety & sourcing	• Apply IoT trials to ensure better food safety	• Facilitate product lifecycle tracking and custom clearance, with focus on verification of the provenance of food
2.3. Productivity at work	• Use AI for meeting scheduling and interpretation services • Facilitate back office services with pattern recognition and clustering for assessment, as well as classification and review of texts	
2.4. Census & statistics	• Evaluate the quality of user input fed into National Population Register, using Natural Language Processing	
2.5. Public procurement		• Proactively publish grants and contribution data in real time • Create a distributed register of invoices to guarantee traceability • Implement smart contract to support public procurement
2.6. Cybersecurity	• Prevent cyber-attacks and improve reporting and early intervention	
2.7. Safety & defence	• IoT-based facility maintenance and management system	

	• Machine learning and computer vision for urgent detection of victims of trafficking	
	3. Environment, natural capital & food	
3.1. Pollution control	• Identify the contributing sources of fine particulate matters • Dramatically reduce pollution with complex causative substance removal device	
3.2. Weather forecast & report	• Prognosis of precipitation with deep learning/neural networks • Automate translation of weather bulletins	
3.3. Natural habitat preservation	• Better characterize, map and monitor ecosystems and habitats important to wildlife, in particular species at risk, using massive archives of satellite imagery • Improve forest inventories precision and predictions at reduced costs	
3.4. Land use / spatial planning	• Construct a 3D geologic map using AI driven implicit modelling • Automate building recognition from laser scanned surface for State land service	
3.5. Energy for climate		• Enable customers of energy service to certify the source of generation from clean energy • Share self-consumption and exchange solar energy with the use of local crypto-currency
3.6. Emergency response / disaster prediction	• Provide early warning in emergency management with real-time extreme forest fires prediction and dynamic flood mapping, using AI and ML • Detect forest fires in real- time using machine vision	• Improve emergencies risk management
	4. Public governance & decision-making	
4.1. Voting & elections		• Reduce costs, improve efficiency and allow greater participation in elections using blockchain-enabled voting system • Use blockchain for selecting finalists of public start-ups competition to enhance trust and security in the voting process

4.2. Intra-government coordination		• Secure communication between the Parliament and the Government for parliamentary questions • Enhance interoperability in document and information sharing among public agencies

Source: Author's elaboration based on responses from Thematic Group (TG) countries.

AI applications and benefits

There are many promising uses of AI for governments and public sector organisations. If correctly designed and implemented, automation tools could be used to enhance the efficiency and quality of many public sector procedures, offering citizens the opportunity to interact with the state in more agile, effective and personalised ways.

More and more government agencies are considering or starting to use AI technology to provide a **human-centric** interface that supports more user-driven service design that best meets the needs of users. Areas involving citizen engagement and social welfare services are seeing an increasing number of AI application experiments. An important driver behind this adoption is to offer citizens a more pleasant and satisfactory experience in their interactions with the public sector, for instance reduce wait times, provide 24x7 and customised support, and increase accuracy of responses. As such, AI is being deployed, for instance through robotics and cognitive automation, to answer questions, query databases, process documents, fill in forms, translate texts and correctly route requests (Mehr, 2017[15]).

These process automation technologies also represent a near-term opportunity for governments to **increase productivity**, slash paperwork burdens, keep costs down and overcome resource constraints, particularly in terms of optimising workforce and shifting civil servants to more complex, value-adding tasks. As an illustration, according to a 2017 study by Deloitte, out of the 4.3 billion hours worked per year in the US federal government, between 96.7 million hours and 1.2 billion hours could be freed up by automation, with potential savings ranging from $3.3 billion at the low end, to $41.1 billion at the high end (Deloitte, 2017).

While in general terms, the initial role of AI in government has been to automate repetitive tasks, the technology can also be integrated into the entire policy making process to **enhance predictive capabilities** for better decision making and policy outcomes. There is a growing trend for experimenting with the use of machine learning and other cognitive technologies for collecting better informed data sets in a much faster and scalable manner, and for analysing data to uncover patterns and make predictions to enable early intervention, fine-tune policy mix and optimise resource allocation. For example, AI technologies may allow for more accurate fraud detection in areas such as taxation and social benefits claims; early identification of outbreaks and surveillance of disease spreading; and improved law enforcement for better prevention of crimes and increased public security (OECD, 2019).

Three main areas of AI applications are discussed below:

Healthcare

The latest advances in computer vision technology are proving crucial for diagnostics in healthcare as it is based on pattern recognition. Countless algorithms are currently trained to detect and classify patterns seen in medical images that contain large, real-time and high-resolution data sets. Combined with the efforts of doctors, some machine learning models can already drastically reduce human error rates and accurately predict the probability of a medical condition, such as heart disease and some types of skin and breast cancers. Predictive tools can further assess the risks that a disease could evolve, which will be particularly useful for infectious diseases that account for a large percentage of healthcare expenditures. AI could rapidly track, analyse and diagnose various infectious processes in

real time, and assist hospitals and healthcare authorities in creating better mechanisms for pattern tracking and disease prevention.

Besides being used as a diagnostic tool, AI-enhanced technologies also prove to be a powerful ally to improve patient care and outcomes, in both clinical and home care environments. Research into robots taking care of patients is producing innovative results. Consumer devices such as wearables, voice assistants and mobile technologies also allow for direct and remote monitoring of patients' conditions and personalised intervention along the care continuum.

Although medicine is not the first field to embrace machine learning, it represents a more complex environment for its implementation due to the heightened stakes and downstream effects in comparison to other scientific disciplines. In 2018, worldwide spending on cognitive and AI systems is predicted to reach $19.1 billion, a 54.2% increase compared with the previous year. In the healthcare sector, most of the $1.7 billion annual investment will be spent on R&D into diagnosis and treatment systems (IDC, 2017[16]). This is in line with 2016's market analysis that predicted the growth of AI in healthcare from $0.6 billion in 2014 to $6.7 billion by 2021 (Frost and Sullivan, 2015[17]).

This data provides a striking picture of the magnitude of AI growth and its impending impact. In the short term, AI developments and applications in healthcare will focus on the automation of rote and labour-intensive tasks such as analysis of medical imaging and then move toward a more quantitative approach providing reliable metrics on disease and response to therapy that can provide patient-tailored medicine. In the long run, AI will likely shift from the simple task-oriented application to more advanced quantification parameters, focusing on patient management, best standard of care, and prognostication.

As the role of AI in healthcare matures it will consequently improve resource allocation and access to care, especially in emerging economies where general access to healthcare and specialised medical assistance are limited.

Transportation

As with healthcare, there are multiple applications of AI in transportation. One of the most transformational shifts has been with the transition to autonomous (self-driving) vehicles powered by AI. Whilst driverless vehicles have now logged thousands of hours of autonomous driving, a number of high-profile accidents have shown that the technology cannot yet permit full autonomy in complex environments.

However, it is not just in taking over responsibility for the driving of a vehicle that AI can add value. AI can play a role in driver assistance systems, safety systems and collision avoidance systems as well as in the routing of public transport and managing of transport infrastructure (ICTC, 2015[18]). AI solutions have been frequently applied to predict and detect traffic accidents and conditions, including by converting traffic sensors to intelligent agents using cameras. In the near future, AI is expected to significantly impact urban infrastructure by providing accurate predictive behavioural passenger analytics, which will feed in the development of traffic demand modelling, support systems for transportation planning as well as the allocation of new construction and maintenance and rehabilitation budget (Stanford, 2016).

Security and safety

The security sector in its broad definition (physical, environmental and digital) can benefit from the development of AI technologies. For instance, in the field of surveillance,

computer vision and natural language processing systems can process large amounts of images, texts and speeches, to detect possible threats to public safety and order in real time. Law enforcement agencies can also use similar technologies to patrol cities, relying on continuously updated data linked to crimes committed in various areas and to other significant variables. Facial recognition technologies have proven particularly relevant in streamlining criminal investigations, detect crimes at early stages and counter terrorism.

In the field of environmental disaster prevention, it is possible to perform natural phenomena simulations that can help authorities decide when and how to intervene. AI systems can be trained with historical and real-time data to forecast the occurrence of extreme weather, provide early warning of natural catastrophes such as earthquakes, floods, volcanic eruptions and hurricanes, build damage predictions and support the construction of disaster-ready infrastructure. A 2018 report of the World Economic Forum (WEF) further illustrates 80 existing AI use cases for meeting critical environmental challenges, from climate change, biodiversity and conservation, healthy oceans, to water security, clean air and weather and disaster resilience (WEF, 2018).

Blockchain applications and benefits

Despite the hype-hope debate around blockchain and cryptocurrency over the past two years, the technology is increasingly considered one of the most innovative approaches in the new paradigm of digital government. By August 2017, over 200 blockchain-related initiatives had been launched or planned in at least 46 countries around the world (The Illinois Blockchain Initiative database). These initiatives include both practical pilots and communities of practice and partnerships to share lessons learnt across countries, regions and sectors.

A recent study by the EU Joint Research Centre assessed seven pioneering blockchain implementations in public services and found that current experiments of blockchain in public sector have largely continued to follow a mostly centralised governance logic, where the government retains a vast amount of the decision-making power (Allessie *et al*., 2019). Interestingly, there is always some level of restriction reserved for public sector players, either on who can commit transactions in the system or on who can validate transactions. This is perhaps unsurprising given that disintermediation (or the removal of central, trusted third-party organisations) is considered by many as the most disruptive innovation of blockchain, particularly public permissionless chains, but none of the projects studied aim at direct disintermediation of any of the public institutions involved in the provision of governmental functions.

Nevertheless, there are still significant incremental benefits that can be reaped in the near term through the use of blockchain in the provision of public services. Two sets of benefits emerge: one relates to **increased transparency and security** through the enhancement of data integrity, immutability and consistency across agencies; the other concerns **efficiency gains** resulting from the reduction of processing time and costs thanks to smart contract automation (Allessie *et al*., 2019).

In economies where third-parties are not always trustworthy and public trust in government runs low – typically due to protracted history of perceived corruption – a significant benefit of blockchain systems would be in the strong support they provide for immutability and non-repudiation. By storing information in multiple copies maintained and synchronised by independent nodes in a peer-to-peer network that is beyond the sole control of a central entity, blockchain can provide higher levels of security and integrity of the data records than most centralised systems stand to offer. By so doing, it strengthens public trust in

governmental processes and recordkeeping, and increases reliability and accountability of the public sector organisations that issue, notarise or store these records – from citizens' birth and civil rights certificates, academic degrees, to electronic health records and asset registers. The use of distributed ledgers and smart contracts will also limit discretionary power and corruption.

On the other hand, public trust in government tends to be higher in developed societies with sound governance of rule of law and robust checks and balances. The benefits of using blockchain would more likely arise from innovative ways of public service delivery and interaction models, which will reduce the cost, time and complexity in public-private information exchanges. For example, smart contracts can be deployed to determine and govern the times at which social aid would be granted, as well as the conditions under which it must continue or stop. Citizens could experience efficiency gains and economic benefits from these more agile and personalised ways of citizen-state interactions. Besides, new models of democratic participation empowered by blockchain, such as futarchy, quadratic voting, liquid democracy and holographic consensus, also hold potential to increase citizens' ownership over democratic processes (Buterin, 2014; Allen *et al*., 2017; Buterin *et al*., 2018; Kotsialou and Riley, 2017).

Furthermore, distributed IT solutions have emerged as a more effective approach to improve **interoperability** and efficiency in inter- and intragovernmental processes. Governments can use blockchain as an information infrastructure for timely and reliable inter- and intragovernmental exchange of information. The architectural set-up of blockchain is in line with the "Once-Only Principle" and can bring operational efficiency by breaking organisational IT silos among public agencies (Allessie *et al*., 2019). The idea is to create a Government Service Blockchain that allows for mutualisation of data in a secure and flexible way without imposing unified process and technology stacks to all involved entities. This can be achieved through the decentralisation of the service and the usage of smart contracts using the blockchain as a kind of "asynchronous communication bus" (Marchionni, 2018[19]).

Common use cases for blockchain in the public sector, although still a niche and experimental, have so far included digital identity and certificates (credentials, licenses and attestations), personal records (health and credit data), welfare benefits or entitlements, asset registries (land titles), digital currencies and payments (Central Bank issued), inter- or intragovernmental transactions, data integration, and supply chain traceability. They generally leverage three core business values of blockchain: recordkeeping and authentication, value transfer, and smart contracts (Deloitte, 2017a). The following will briefly present four such examples.

Identity management

One fifth of the world's population today still live without a legal or officially recognised identity (World Bank, 2017). Besides, individuals and organisations are often not in control over their own identities. Theft of personal information is common, leaving centralised data systems vulnerable to hackers. Further, identity management has long suffered from differing attestation processes and entry points that prevent economic management and seamless, secure and scalable inter-agency sharing of data. Blockchain could be used to establish secure, self-sovereign digital identities for citizens and businesses and enable efficient transactions across a wide variety of activities. Users can also have individual and secure control over which identity elements are shared for which purposes. More than being a simple use case of blockchain, government-attested decentralised identity will also serve

as enablers for new public services provision like electronic voting or access to public infrastructure.

Asset registries

In many countries, the ownership license and registry processes are still paper-based and fragmented, making transactions costly, inefficient, time-consuming and prone to fraud. By securing a unique and non-corruptible record of ownership status and transactions on blockchain, a reliable record can be created, for a piece of land, a property, and any other valuable documents such as contracts. This also decreases time and cost in the registration process by reducing the number of intermediaries required. Several countries among the TG have been exploring blockchain-based solutions for registering land titles and validating property-related government transactions.

Voting

Current voting systems are onerous to run and maintain, owing to high costs in ballot printing and electronic voting machines. Increasing threats of cyberattacks and ballot rigging also compromise the election results. Blockchain has the potential to enable new methods of voting that will combine decentralised digital identity management, anonymous vote-casting, individualised ballot processes and verifiable ballot casting confirmation (Deloitte, 2017a). Some countries have experimented with blockchain-enabled voting in a bid to reduce costs, improve efficiency and allow greater participation in elections, including remotely. Nonetheless, truly transformative services which enable decentralised voting or civic governance without direct involvement of governments are missing from the current landscape (Allessie *et al*., 2019).

Customs clearance

Customs in cross-border logistics span a range of government and business operations and involve multiple transactions. A prominent pain point has been the absence of effective traceability, transparency and predictability of shipments coming in through the nation's ports (Deloitte, 2017a). The process of customs clearance and payment is often time-consuming and still involves manual processing in many places. Using blockchain can improve security, data transparency and consistency, and auditability of recordkeeping throughout the supply chain. It would help custom agencies worldwide eliminate delays in identifying and processing international shippers and improving inspection target.

Examples of AI and blockchain experiments in TG countries

Australia is exploring innovative ways to securely and efficiently deliver government services using modern technologies such as blockchain, artificial intelligence and data analytics. For instance, The Digital Transformation Agency has released a set of guides and tools to assist government agencies investigate potential blockchain applications. The Australian Stock Exchange is using distributed ledger technology to upgrade its electronic shares sub-register, clearing and settlements system. Data61 has entered into a consortium with IBM and Herbert Smith Freehills to develop a national blockchain for smart legal contracts.

Argentina are rolling out pilots to automate assisted service delivery to citizens and to recognise patterns of claims. A fully functioning AI system has been deployed within justice and public administration to drastically reduce time in processing judicial files and human errors (Box 3.2). Another pilot project is being deployed to train AI system to obtain

a virtual assistant in aquaculture. The project developed jointly by the Government Secretariat of Science and Technology and the private sector seeks to combine techniques of natural language processing and machine learning to reveal key information to solve problems and make business decisions with greater information. As a pilot test, it consists of training the selected technology in the interpretation of questions so that it is able to understand the language of this specific topic and can give correct answers using information from different sources (e.g. scientific papers, journalistic articles, business).

Box 3.2. Prometea – A fully functioning AI system within Argentine Justice and Public Administration

Prometea is a system applied in the Public Ministry of the City of Buenos Aires to help solving cases on behalf the Court of the City of Buenos Aires. It is also applied to public contracts. The system combines innovation layers: natural language processing, automation and prediction. Prediction success rate is 96% in cases related to the right to housing, people with disabilities, and labour law issues (67% of the cases we work with). Prometea simplifies the data and information flow and exponentially accelerates the production of needed documents. For instance, Prometea can help solving 1000 judicial files in 7 days rather than in the 83 needed without it. In addition to time optimisation, Prometea reduces typing and writing errors by 99%. Up to now, 161 cases have been resolved by using this system (97 of them with prediction). Within other functionalities, the system has the power to reduce to 2 minutes what is done manually in 3 days. In some cases, efficiency is optimized by 143,900% (2 days vs. 2 minutes).

In the Constitutional Court of Colombia, which received thousands of files daily, the time destined to select urgent cases was reduced from 96 days to up to 2 hours since the application of the machine learning technique system. Prometea reads, analyses, detects and in a few seconds suggests which are the priority cases within health related matters. All this, under human supervision. Moreover, the tool is designed to automatically create multiple documents. Thus, 14 documents can currently be created in 16 minutes, when before it would take a person 2 hours and 40 minutes of work. The efficiency in this case is increased by a 937%.

Prometea is also designed to be applied for example in the Inter-American Court of Human Rights and the Argentine Association of Women Judges. The system has also been presented in other institutions, international organisations and universities, including: French Council of State, United Nations, Supreme Court of Justice of Argentina, Supreme Court of Justice of Costa Rica, Public Prosecutors Office of the City of Sao Pablo, Administrative Court of Lombardy, and University of París 1 (Panthéon-Sorbonne), Oxford University, Alma Mater Studiorum Universita di Bologna and Universita degli Studi di Milano.

Canada's Public Health Agency is developing a "Global Public Health Intelligence Network" that predicts when a disease outbreak is about to happen, using a number of data sources from emergency room records to weather forecast. Health Canada (HC) is assessing how AI can be used to decipher user-generated data on various social media platforms (e.g. Twitter) in order to generate actionable insight. Building on the experience of AI use by marketing firms to prove the effectiveness of marketing on clients, HC is seeking to prove how AI can be used to determine if risk communications are effective in changing behaviours of patients, consumers and healthcare providers.

Chile is currently running a pilot project using blockchain technology to review the purchase orders of public procurement platform[9] and ensure a higher level of transparency of the process, by functioning as a kind of virtual notary that certifies that these documents have not been altered in an improper manner.

Colombia has developed blockchain solutions to improve emergency risk management. Moreover, the ICT Ministry is working with the agency in charge of public procurement (Colombia Compra Eficiente) to develop a virtual assistant based on Watson technology in order to solve FAQ. The Inspector General's Office has teamed up with the World Economic Forum and the Inter-American Development Bank to explore how blockchain can improve transparency and integrity in school meal procurement[10].

Estonia's State Shared Service Centre and the Ministry of Culture have developed an ET based system to detect double funding in public procurements.

Finland recently launched a Chabot service for foreign entrepreneurs called "Starting up smoothly" to break governmental silos and help foreigners settle in Finland and start a business. It is composed by three Chatbots: one for helping to get residence permit to live in Finland, one for advising how to set up a company and one to provide information on business and work-related taxes in the Country. The government is also promoting the adoption of innovative data solutions and platforms, in areas such as connected and automated driving, automated transport, mobility as a service, personal data management systems (MyData), use of location information (satellite and mobile data), real-time economy and the use of energy-related data (Box 3.3).

[9] For more information visit: www.mercadopublico.cl

[10] For more details visit: https://www.weforum.org/agenda/2019/05/heres-how-blockchain-stopped-corrupt-officials-stealing-school-dinners/

Box 3.3. The use of open data as a strategic tool for the enhanced use of AI in the public sector

Examples from Mexico (datos.gob.mx, Datalab and URBEM)

The availability and use of quality data are considered as being vital for the most efficient use of AI programmes and research related to emerging technologies. Mexico has made AI-related open data an essential element of its National Digital Strategy and is promoting its use for AI-related projects.

Open data access and sharing are promoted via the **datos.gob.mx** platform. This platform aims to "create a collaborative ecosystem of public services, encouraging innovation and entrepreneurship by turning information traditionally held by the government into an asset of social value."

"DATALAB" is an initiative of the Coordination of the National Digital Strategy of the Office of the President of Mexico designed to promote the use of data science, AI-related technologies, and Open Data to stimulate the design and implementation of evidence-based public policies by creating capacities within and outside of the Mexican Federal Government.

Several AI initiatives are being deployed in Mexico to enhance public services and citizens' life at both the national and local level. URBEM is a tool launched by the state of Nuevo León's Undersecretary of Legal Affairs and Citizen Services to provide inhabitants of the region an AI-enabled chatbot in Facebook Messenger to accurately answer their administrative requests, give access to useful documents while enabling feedback gathering. Through these functions, URBEM can centralise data more efficiently and offers an internal administrative dashboard to be used for internal management.

Italy has launched a series of Pre-Commercial Procurement (PCP) initiatives at national level to support the implementation of AI solutions to improve public service delivery's efficiency and effectiveness. It is also leveraging on blockchain's power to digitalise the recognition process of academic qualifications (Box 3.4).

Box 3.4. CIMEA in Italy - blockchain technology applied to the field of recognition of academic qualifications

CIMEA (Information Centre on Academic Mobility and Equivalence) is the official Italian Centre within the NARIC (National Academic Recognition Information Centres) – network of the European Union, and within the ENIC (European National Information Centres) – network of the European Council and of UNESCO. Since 1984 CIMEA[11] performs its activity of information provider and advisory body on the procedures of qualifications' recognition and on themes linked to Italian and international higher education and training. CIMEA's Credential Information Service (CIS) is a credential evaluation service of certification and comparison between Italian and foreign

[11] CIMEA supports academic mobility in all its forms and owns an international document centre and specialised databases on foreign higher education systems, on the types of qualifications of every country and on the national legislation related to higher education.

qualifications, with a view to make qualifications increasingly more comprehensible and recognisable in a national and international context.

CIMEA has decided to utilise the power of blockchain technology to digitalise the process of certification of qualification (based on Lisbon Recognition Convention principals) and for the CIS to eliminate any possibility of falsification of given certificates and qualification information. The chosen approach is to create an ecosystem built on an interlaced distributed network of information that allows to precisely identify the credentials and certification of any registered user and provides CIS services, certifying their truthfulness. A modern distributed technology and strategic process flow approach takes success stories from other markets and adapts them to the certification ecosystem utilising the latest technologies as AI and blockchain, such as Diplome.

The Diplome ecosystem running on a permissioned blockchain network where every stakeholder participates to building-up the ecosystem based on its role: end user, certifying authority, certifiers. Certification Authorities are further divided in 'Direct Certification Authorities' that are entitled only to issue certifications for users belonging to their organization (e.g. Universities) and 'Cross Certification Authorities' that are entitled to issue certifications on every user within the Diplome network (e.g. NARICS). Certification issuers are handled by a blockchain oracle that acts as source of truth for authorized certifiers. Each of the stakeholders has specific permissions on the network based on its related entitlement. In case an organization wants to participate to Diplome, an easy setup based on free and open source software allows integration in no time.

Users, when participating to Diplome, are assigned a personal meta-wallet within the blockchain that will be their secure repository for every document related to their education. This account belongs to the user and any interaction can only be authorised by the user itself utilizing the cryptographic key assigned at time of the account's creation. The account is fed by external smart contracts handling different tasks. Whenever the user itself, his organization or a cross certification authority adds a document related to the user education, a dedicated smart contract is activated. The task of this smart contract is to verify that the appropriate permissions (e.g. organization, user information) and data structure (e.g. appropriate organization characteristics) are used together with consistent metadata (e.g. this certification is not in conflict with other certifications). Diplome is in production since early 2019 and already thousands of users have setup their Diplome wallets securely loading and storing their certificates within it.

Korea is developing nursing robots, low-cost, high-precision diagnosis technology to overcome dementia, and safety technologies to prevent patients from falling or getting lost.

Latvia has created a web-based all-time available virtual assistant called UNA to help clients register enterprises, liquidate companies and check documents much more conveniently (Box 3.5).

Box 3.5. UNA, a web and Facebook Messenger based virtual assistant for Enterprise Register of Latvia makes talking to the government effortless

In June 2018 the Latvia's Register of Enterprises opened the first virtual assistant of public administration (UNA). The virtual assistant provides written replies to the frequently asked questions regarding registration of a new subject, progress and liquidation of the submitted registration documents. The virtual assistant of the Register of Enterprises UNA is a customer-oriented tool, available at any time of the day and night and using clear and understandable language for communication and a business-like communication style. It is available on the website www.ur.gov.lv, as well as through the Facebook Messenger application. It is important to indicate that the virtual assistant UNA can be conveniently used at any place, when smart devices are also be applied for search of information, because it operates in the responsive design.

Portugal is going to use AI to maximise tele-dermatological screening, to be developed through a partnership between the Fraunhofer Association in Portugal with the SPMS (Shared Services Ministry of Health). The project aims to assist General Practitioners in Primary Care Units (PCU) to diagnose skin lesions using a vision based mobile application. Suspicious cases will be reported to dermatologists in Hospital Dermatology Departments where an AI powered Risk Prioritization and Decision Support platform will help prioritise cases for further specialized analysis.

Along with that, Portugal is implementing a project that aims to help minimize response time of emergency medical services. Predictive models will be developed to help anticipate service demand by combining existing historical data and context sensitive data from several sources (e.g. weather). In addition, a project is running for the identification and forecasting of the demand for hospital emergency rooms. The main goal is to identify, in a timely manner, significant changes in patient-admissions to emergency care units. Medical and non-medical related datasets will be used to produce a Probability Indicator for each individual hospital emergency admission unit, thus effectively reducing waiting times, optimizing resources, and reducing costs.

Additionally, Portugal has also held a start-up competition event to select innovative business cases that address the 17 Sustainable Development Goals. Blockchain technology was used to allow the public to select finalists and vote for the winners (Box 3.6).

Box 3.6. GOVTECH – blockchain technology in voting process

GovTech was a public competition that took place in Portugal in 2018, with the goal of rewarding innovative products and services of start-ups that addressed at least one of the 17 Sustainable Development Goals. To participate in the competition, start-ups had to submit functional prototypes of products or services, based on feasible business cases. The public voted to choose six finalists, through an innovative voting process using blockchain technology. From those six finalists, a jury of experts selected the three winning projects.

The initiative was coordinated by the Administrative Modernization Agency (AMA), which is the public sector organisation responsible for the promotion of administrative modernization, under the Secretary of State Assistant for Administrative Modernization (SSAAM). The Camões Institute from the Ministry of Foreign Affairs also played a central role in coordinating the international cooperation and monitoring the 2030 Agenda in Portugal.

The transparency and security of the voting process of this competition was based on an Ethereum private experimental network, using blockchain technology, and a cryptocurrency called GovTech was created to simulate the investment on the competing projects. The process was very simple, after creating an account on the website, the citizens automatically had a virtual wallet that they could manage, and were able to receive badges for doing determined actions. Each badge had a certain amount of GovTechs associated. For instance, when a citizen created an account, he received a badge with 100 GovTechs. If the login was made using the DMK (Digital Mobile Key), instead of the Citizens Card, he received an extra badge of 200 GovTechs.

The project management was the responsibility of the Digital Transformation Team in AMA, but there was also a procurement process that resulted in the hiring of a private company. Bright Pixel was the responsible for the development of the website of the initiative and the voting process though a web platform and app based on a blockchain infrastructure, with the creation of the cryptocurrency and an exchange market.

This initiative provides a great example of using blockchain to bring trust and security to the voting process, the experiment its application in the voting / investment phase, which worked as a learning experience for AMA. It was the first time a governmental initiative used blockchain, so the goal was also to test the potential of this emerging technology and produce some lessons to be used in future projects using this technology.

Regarding the Govtech competition in itself, in this first edition 113 prototypes were approved and 1744 people/investors were registered on the initiative website. In the end, there were three winning projects.

New Zealand has been experimenting with machine learning to identify patterns in immigration and visa irregularities, with the aim of informing the design of fair and effective operating procedures.

Slovenia ran a pilot project using big data tool to improve human resource efficiency within the Ministry of Public Administration. The pilot proved that big data could provide an effective and solid basis for predicting process, planning policies and decision-making process on all managerial levels in public administration based on existing internal data sources combined with some external data (Box 3.7).

Box 3.7. Big Data Analysis for HR efficiency improvement at Ministry of Public Administration of Republic Slovenia

In Slovenia, the pilot project "Big Data Analysis for HR efficiency improvement" was established in 2017 as part of the development-oriented strategy supporting ICT as an enabler for development of data-driven public administration. It ran within the Ministry of Public Administration of the Republic Slovenia (hereafter MPA) in collaboration with EMC Dell as an external partner and the overall development time was 10 months.

This pilot project was launched to learn what big data tool installed on the Slovenian State Cloud Infrastructure could enable research of HR data of the ministry to improve its efficiency. Therefore, anonymized internal data sources containing time management, HR database, finance data and Public Procurement were combined with external resources using postal codes of employees and weather data to identify potentials for improvement and possible patterns of behaviour.

The results showed that there is considerable potential for improvement in the field of HR and lowering costs in the field of public procurement within the MPA.

The pilot project confirmed that the use of big data tools could provide an effective and solid basis for predicting process, planning policies and decision-making process on all managerial levels in public administration based on existing internal data sources combined with some external data. Gained experience also showed that big data analytics could help improve the efficiency of MPA in decision-making by using different statistical and quantitative analysis.

MPA has been continuing the project, first spreading the gained experience and knowledge of big data tools among its employees and sharing it to other ministries and administrative authorities within the Slovenian Public Administration.

Spain is developing a distributed ledger of public procurement tenders and automated evaluation of the tenders. The goal is to create a system for submitting binding offers that complies with Spanish procurement regulations (Law 9/2017), using distributed ledger technologies. These offers are initially limited to a type of contract that may only be awarded using quantitative evaluation criteria.

Sweden's Migration Board has begun to work with a few pilot projects and sees opportunities both to improve process involving users as well as internal processes. When in-person meetings are not required, some degree of automation can be applied in the process of information management.

Uruguay has designed and developed the Cloud of the Presidency Office, which offers IaaS, PaaS, and SaaS to all its agencies. Currently the cloud host more than 3,500 virtual machines. In 2018, working together with the state-owned telecommunications company (ANTEL), a government cloud service was launched to provide services to the public sector. The eGovernment agency Agesic has also developed a user-friendly guide explaining how to use blockchain to public sector organisations (Box 3.8).

This guide comprises assessment tools for IT public sector organisations to evaluate whether blockchain meets their needs. .

For example, the document "Blockchain yes or no" includes a set of questions that assesses different technical and non-technical aspects of services to decide whether Blockchain is an interesting technology for the chosen use case.

Another example is the document "Blockchain - A flowchart can help", which with the help of a flowchart, helps to decide whether blockchain is an appropriate technology to use in the given case. If appropriate, the document will guide the agency or institution to define functional aspects such as the scope, relevance and characteristics of the implementation.

Box 3.8. Blockchain, beyond the hype: the experience of Uruguay

In the case of Uruguay, and after comparing different available options, Hyperledger Fabric was chosen for experimentation. This is an open source tool with a simplified and more flexible implementation of Smart Contracts and configurable consensus and membership services.

A proof of concept on time-stamping for files was developed. Lessons learnt enabled Agesic, the agency responsible for leading the national digital government policy, to develop a guide by which institutions can assess the convenience of using blockchain and which type of blockchain would be the most appropriate. This tool has already been used for cases such as tracking supply chains with the foreign trade one-stop-shop.

Based on the experiences acquired, a strategic plan is being prepared to harness the opportunities provided by blockchain in the Government of Uruguay. The plan involves development of blockchain based on shared assets to be incorporated into services by public institutions and a platform for the deployment of BaaS (Blockchain as a Service) solutions.

Uruguay developed an initiative called IA-CKATON, which objective is to bring together innovative ideas use of AI to improve State services. In addition to promoting experimentation and development of the best projects in AI, they seek to encourage entrepreneurship and collaborative work in an environment of healthy competition.

In the 2019 edition, with the support of Red Gealc, the activity will be a regional competition involving Chile, Panama, Paraguay, Peru, Dominican Republic and Uruguay. Participating teams are requested to generate innovative pitchesbased on the themes of the different action areas of the 2020 Digital Government Plan.

IA-CKATON targets participants from academia, the public or private sector, or civil society. Each participating country will carry out its own IA-CKATON instance and will then choose a national winner; the winners of each country will participate in the regional grand final and the finalist will present its work at the annual meeting of the Gealc Network in Buenos Aires, Argentina, in October 2019.

In the previous edition (2018), 7 finalist teams participated in the IA-CKATON, which proposed solutions to different social, educational and occupational issues. This year's objective is to broaden the ecosystem by also inviting students from technological universities to think and design proposals that contribute to the improvement of public digital services.

Agesic and other public agencies are developing an "open" environment for accelerating and testing data science and machine learning (CD/AA) solutions. The objective is to provide access to state-of-the-art experts, infrastructure and software through open

environments for CD/AA testing, acceleration, experimentation and proof-of-concept testing by enterprise groups and other collectives.

Box 3.9. How the Department for Transport used AI to improve MOT testing

The Driver and Vehicle Standards Agency (DVSA) in the UK wanted to use a more intelligent, data-driven approach to better target their resources and ensure high MOT standards. MOT tests check that cars meet the minimum road safety and environmental standards required by law. Each year, 66,000 testers conduct 40 million MOT tests in 23,000 garages across Great Britain. A team of 300 DVSA auditors are responsible for ensuring garages are applying the MOT standards. This process is resource intensive and does not allow for targeted inspections.

The DVSA applied a clustering model against garage test data from the last 3 months. This grouped MOT centres based on the behaviour they show when conducting MOT tests, creating a risk score for each garage. The algorithm combined the risk score with historical data on correct application of MOT standards, allowing the DVSA to rank garages and their testers, and helped the DVSA identify regional trends. The DVSA refreshed test data every 3 months giving auditors a 3 month windows to visit garages.

The DVSA can now target their resources at the garages and testers with the highest risk score. By identifying areas of concern in advance, the examiners' preparation time for enforcement visits has fallen by 50%. There has also been an increase in disciplinary action against garages, meaning standards are now being better enforced. As more garages are delivering better MOT standards, there are more cars on the road that comply with roadworthiness and environmental requirements.

AI is widely used across both central and local government in the **UK**. For example, the Department for International Development is using AI and satellite technology to provide better population estimates. This improves the planning and delivery of aid operations and vaccination projects. The UK's 'smart motorways' use neural networks to anticipate and manage traffic flow based on data on road conditions from embedded sensors. AI is being deployed to improve diagnosis of diverse health conditions, such as age-related macular degeneration, lung cancer and heart disease, as illustrated under the AI and Data Grand Challenge

Early Diagnosis Mission. Machine learning deployed by HM Revenue and Customs is being used to detect potentially fraudulent activity relating to tax. GOV.UK, the government's main platform, uses supervised machine learning to help organise content so that it is readable to technologies of the future. It's possible to see or hear our progress in this area now: if you ask the voice assistant technology Google Assistant how to renew a passport, you'll be informed by GOV.UK content.

Moreover, in 2018, the Government Digital Service and the Office for Artificial Intelligence (OAI) worked together to deliver the Artificial Intelligence for Government Review. The Review identified potential use cases for AI across government and explored the barriers that exist to more widespread use.

Box 3.10. Use of machine learning for sustainable data exchange

In Slovenia, a central system for data exchange exists as a powerful, flexible and reliable technical solution, providing a solid basis for interconnection of base registers and for practical implementation of once-only principle.

The common data exchange system was originally developed in 2012 for e-social security and is now being used by many public sector institutions as a tool for efficient and safe data gathering and data sharing. For example, all public procurement procedures are using it, e-government portal, anti-money laundering and anti-corruption service... Central population register also distributes its data using these mechanisms. Over 10 M transactions were processed last year (in a country with 2 M population). Ministry of Public Administration is responsible for developing and maintaining the solution and providing the service. Various measures and levers are used to ensure high uptake of the system.

Extensive use also causes risks for reliable and stable performance, because the workload (number of enquiries in a given time frame) is not constant, and the channel capabilities are always limited. The system must be able to efficiently handle unpredictable temporary peaks. On one side, the clients requesting data must enjoy agreed and expected response times and on the other side, the datasources must be protected from too heavy burden threatening to flood their limited server capabilities.

A new feature was developed in 2018, which utilizes machine learning techniques to optimize the data flow. It captures all the incoming traffic in a kind of a pool and then controls the forwarding intensity by knowing the past and current performances of the connected systems. It is constantly monitoring the performance of integrated systems in real time, incrementally learning from its "real time big data" flow and using the knowledge to optimize the intensity of calls. The machine learning system uses traditional approaches and is implemented under the IBM CRISP-DM Machine Learning Scheme. Incremental learning is carried out using the algorithms of the Java Machine Learning Framework - WEKA and MOA (Massive On-Line Analysis), allowing predictive modelling by flow data mining.

This new learning and throttling system allows to monitor and improving the utilization of datasources. This ensures maximum throughput of the system, its stable performance and the timely acquisition of data.

The results of predicting the datasource performance are higher average speed of data inquiries and minimum queueing. High stability, robustness and technical sustainability of the entire system is consequently ensured.

4. Discussion and preliminary lessons learnt

Emerging and disruptive technologies are often over-hyped at early stages of inception. Governments often feel forced to show enthusiasm and demonstrate that they are adopting the technology, turning it at times into a flagship initiative but without having completed a sound analysis and formulated a real value proposition to argument and justify the adoption. This has been the case of AI and blockchain in recent years. Yet, as many other technological breakthroughs, these emerging technologies are still in a constant state of flux, and governments are just starting to discover how they work and how they can be applied to resolve specific problems. Rather than (over) promoting the technology, it is important to focus on the real needs and complete a sound analysis on the potential benefits in responding to those needs, and on the related implications (i.e. from a political, legal, security perspective). Pros and cons associated with the use of any emerging technology should be addressed methodically and with an understanding of real potentials and implications, including the challenges and the opportunities, which are specific to the public sector.

Based on findings from the 20 TG countries, this section discusses the major obstacles to the adoption and application of emerging digital technologies in the public sector. It will then offer a set of preliminary lessons learnt and further research questions to help governments better navigate their digital transformation agenda.

4.1. Major barriers to public sector adoption of emerging digital technologies

Participants of the TG have identified three types of barriers to the adoption of emerging digital technologies across public sector organisations (Figure 4.1). These include:

- **Technical and practical challenges**, such as the availability of quality data, lack of common standards and the level of interoperability between different IT systems;
- **Resource and capacity constraints**, for instance, the lack of specific skills in public administration, low digital literacy in society and inadequate level of investments and funding for R&D or early experiments;
- **Institutional, legal and cultural barriers**, particularly unsuitable legal and regulatory framework, resistance to change and insufficient political commitment in part due to risk aversion.

Among these, the absence of common standards and suitable legislation are the most quoted obstacles, followed by skills shortages in the public sector, , lack of institutional buy-in and inadequate investment and funding. More than two fifths of the surveyed participants identified with challenges that are institutional, legal or cultural in nature, while just beneath a third mentioned technical and practical constraints. The key challenges for public sector organisations today consist of understanding what they can do with emerging technologies and how to apply them to optimise specific services.

More broadly, a major constraint identified in the use of emerging digital technologies by public sector organisations is the lack of governance in this specific field. Still faced with institutional setup that are a legacy from the past, where choices around the adoption and deployment of technology are sector based in vertically integrated administrations, various

participants of the TG are currently experimenting governance models that shall assist the public sector in the introduction of ET in line with the overall governance needs of a digital government. The aim is to facilitate the emergence of a whole-of-government and coherent approach to the use of technology to simplify public services and thus overcome existing difficulties, such as lack of relevant expertise inside the public administration, as underlined by the OECD Recommendation on Digital Government Strategies (2014).

Figure 4.1. Major barriers to adoption of emerging technologies in public sector

Source: Author's elaboration based on responses from Thematic Group (TG) countries

Technical and practical challenges

There are many technical barriers that governments need to overcome, for instance, more investment is needed to upgrade legacy IT systems to reduce risk of incompatibility in the integration of future software. There is also a considerable lack of standards. For instance, **data availability and interoperability** are often limited across public sectors as stove-piped organisations manage data within silos, and as a result, it turns out quite difficult to identify or access multiple data sources.

Furthermore, the **quality of data** is a crucial precondition for all AI and blockchain projects, sometimes even more important than the quantity of data. It has been observed that the importance of quality data (or the lack thereof) is often raised as the most important aspect that contributes to success or failure in an AI initiative. Some have even gone as far as to say that most governments simply are not ready for AI, and that they first should focus on getting their data in order (OECD, *AI primer*, forthcoming). In this regard, the OECD AI Recommendation places a focus on putting in place a digital ecosystem for AI, including infrastructure and mechanisms for sharing AI knowledge (including data). Similarly, the quality of data input at the origin will directly affect qualify of the data on a blockchain and hence the quality of any analytical results derived from that data . (Welby, van Ooijen and Ubaldi, 2019[20])

It is also important to note that a large part of most blockchain applications in governments or enterprises today is about integrating the distributed ledger with disparate and legacy centralised systems that continue to store off-chain data for reasons of scalability (big data) or confidentiality (private data). It is important to bear in mind that blockchain is usually just one layer of a broader, often sophisticated IT system, and that many classic software engineering problems will still need to be dealt with in the process of design and implementation (Staples *et al*., 2017).

Resource and capacity challenges

Public sector staff and management are considered to be one of the most important drivers of public sector innovation. However, initiatives to develop, motivate and deploy internal talents today are largely inadequate. The level of **digital capabilities** and awareness of the impact of technology is generally lower in public sector. With an aging Baby Boomer workforce, some countries are facing particularly acute personnel challenges in the public sector, whilst an important share of the workforce continues to be overburdened with mundane, repetitive tasks. Automation could potentially ease some of these resource constraints, and younger, tech-savvy workers, such as data scientists and subject matter experts, would need to be hired to bolster competencies in the public sector.

Besides limited knowledge on latest technological advancements, managing digital transformation projects is fraught with risk and complexity, which requires **specific skills** (such as data analytics, user experience and interface, etc.) that are often in short supply in public administrations. Moreover, some TG participants mentioned that there is still a shortage of adequate **funding**. For instance, Necessary computing resources should be ensured for an AI project. While cloud computing solutions may suffice for certain AI applications, more heavy data crunching might require more expensive graphical processing units.

Institutional, legal and cultural challenges

The progress of digital transformation of the public sector typically encounters hurdles at the institutional / organisational, legal and cultural levels. The following will address three specific challenges: risk aversion, resistance to change, and regulatory hurdles.

Risk aversion

An important factor for governments to consider is understanding the right time to take a risk with an ET for experimentation and when to consider something sufficiently well understood and mature for it to become “mainstream” and applied more broadly across different government services. The fear of making mistakes, linked to experimentation and testing, is deep rooted in the public sector and can sometimes act as a barrier to innovation and calculated risk-taking, resulting in inaction or insufficient leadership commitment(OECD, 2017b). Wardley Maps[12] provide a valuable technique for gauging the maturity of different technologies and understanding where governments could best focus their energies to maximise value to their stakeholders (Wardley, 2018[21]).

[12] A Wardley map is a map of the structure of a business or service, mapping the components needed to serve the customer or user. It is named after Simon Wardley who claims to have created it in 2005.

Resistance to change

The ability to drive change and align people around a shared vision is crucial for advancing digital transformation of the public sector. Resistance to change appears particularly strong in some applications of blockchain, as its implications on decentralisation are incompatible with today's institutional structures of governments (Allessie *et al*., 2019).

Resistance to change stems from a variety of factors, including: *fear of failure or being replaced* by automation and disintermediation technologies; *fear of radical transparency* brought by technologies like blockchain, whose traceability can fully expose errors and incompetence; *lack of innovation mindset* resulting in absence of change leadership and biased perception of innovation possibilities; *inadequate incentive structure* penalising or failing to recognise initiative-taking; and *rigid institutional setups*, organisational rules or bureaucracy discouraging experiments of new approaches or different governmental sections to work together.

In recent years, the fear of being replaced has gathered much public attention. There is growing recognition that technologies like AI and blockchain will change the nature of work as they replace and/or augment components of human labour, while simultaneously creating new tasks for humans. Properly handling the potential negative employment implications of automation technologies can sometimes make or break the progress of digital government transformation. Needless to mention, continuous education, training and skills development programmes should be provided to secure institutional buy-in and facilitate short and long-term transitions as people move from one job to another.

Regulatory Challenges

Digitalisation challenges the rationale for traditional approaches to the design, enforcement and governance of regulation. As both an enabler and a user of emerging digital technologies, governments are facing the headache of how to regulate them to maximise their innovative potential while minimising the risks for end users (OECD, 2019d).

There are growing concerns and increased awareness around the challenges AI is creating in terms of **privacy, security, fairness,** and **ethical issues**. Given their reliance on historical and societal data, the use of algorithms can propagate existing biases or make them self-fulfilling in controversial policy areas, such as in recruitment, criminal justice or recidivism prediction, where gender bias, racial discriminations or other stereotyped associations might recur (Cairns, 2019[22]). With AI-enabled services often targeting the most vulnerable members of society who may be least able to navigate or deal with the complexities of new technologies, and in line with the OECD AI Recommendation, those responsible for designing and operating these services should ensure their transparency, fairness, robustness and accountability (OECD, 2019c). There would be additional challenges on how to regulate and enforce the accountability of AI systems.

Privacy and **confidentiality** are also a challenge for certain types of blockchain applications. Generally, a necessary trade-off will have to be struck between decentralisation and privacy settings. Permissionless chains offer radical transparency and greater independence from centralised authorities than permissioned chains, but could entail risks to the exploitation of personal data (Berryhill *et al*., 2018). The solution has usually been storing identity information off-chain to preserve its confidentiality, although this comes at the expense of transparency and independent auditability and partly undermines the distinctive benefit of blockchains in providing distributed trust. This may

also create a single point of failure and reduce other benefits of a distributed network, such as system availability and reliability.

Furthermore, traditional notion of **liability** is challenged in the case of smart contracts. In fact, incompatibility between blockchain-based solutions and existing legal framework is a major barrier to unlock the transformative potential of blockchain (Allessie *et al*., 2019). For instance, the legality of digital signatures and notarisation via cryptographic proofs is currently unresolved. It is also difficult to scale cross-border adoption if legal harmonisation is required. Lack of regulation and governance standards therefore hinders the development of more disruptive blockchain services beyond a proof-of-concept or early pilot phase. Moreover, when a breach of smart contract occurs, it may be caused by either of the contracting parties, or inherent flaws within the contract itself, due to coding or design errors. In the latter case, current laws and regulations have difficulties in apportioning and attributing responsibility for damage caused by technology to end users.

4.2. Preliminary discussion of key enabling factors

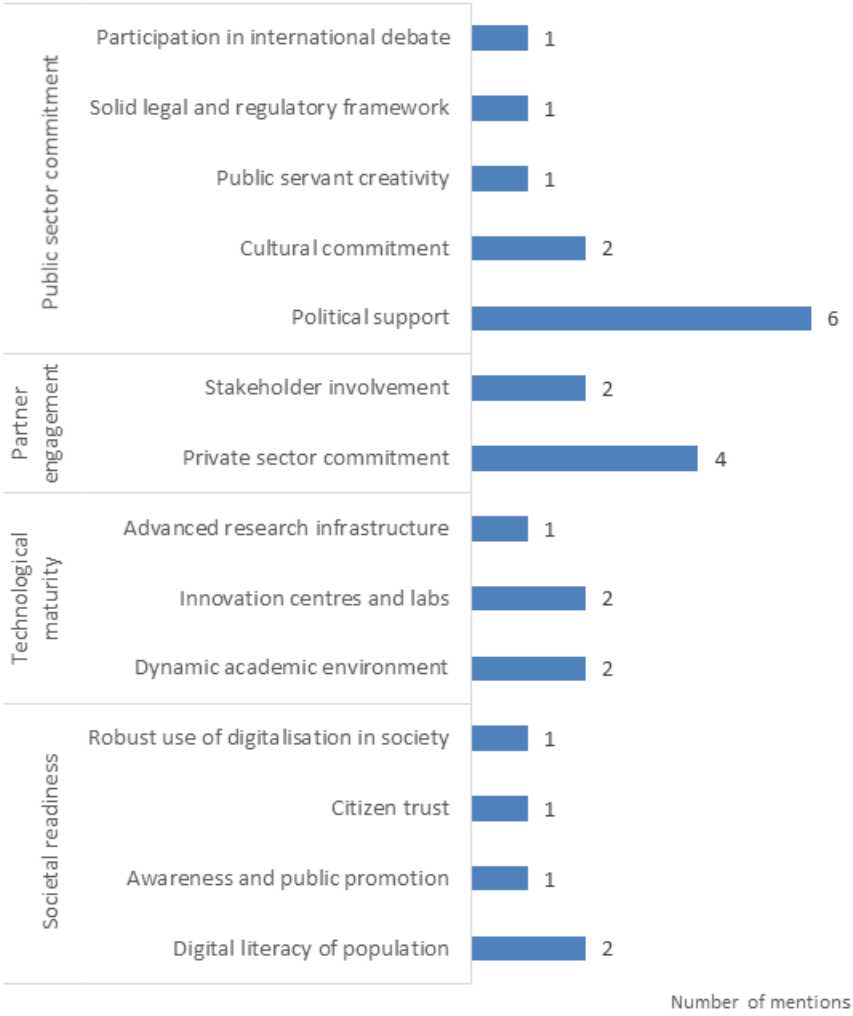
Governments and public sector organisations can leverage digital technologies to better inform and steer decisions for the benefits of businesses, citizens and societies. These developments can foster significant advances towards a more anticipatory, evolutionary and collaborative public governance that is capable to deliver responses to changing needs with greater agility. However, a paradigm shift is essential to adopt transformative approaches to public service delivery and value creation, which can still guarantee equitable share of benefits across societies (OECD, Forthcoming[23]). Participants of the TG have identified four sets of enabling factors for facilitating public sector adoption of emerging technologies (Figure 4.2). These include:

- **Public sector commitment**, most importantly political support, followed by cultural commitment (to innovation and reforms), civil servant creativity and sound legal framework;
- **Partner engagement**, from the private sector as technology provider or co-developer and from various ecosystem of stakeholders[13];
- **Technological maturity**, typically a dynamic academic environment that spurs creativity, presence of innovation clusters and advanced research establishments;
- **Education and societal readiness**, as measured by the level of digital literary of the population, public servant's expertise and buy-in of emerging technologies, and degree of digitalisation in different sectors of the society.

Among these, political support is the most quoted enabling condition, followed by the commitment of private sector actors. Above two fifths of supportive factors relate to public sector commitment. It is also worth mentioning that political support and stakeholder engagement, or the lack thereof, have been mentioned both as an enabler and a barrier to public sector adoption of emerging technologies. The following section will focus on discussing two types of enabling factors: public sector commitment and partner engagement.

[13] Countries underlined the importance of involving both public and private sector actors, from academia, non-profit, industry, and different levels of government.

Figure 4.2. Major enablers for the implementation of ET solutions



Source: Author's elaboration based on responses from Thematic Group (TG) countries.

The OECD identified five key priorities to create enabling environments for trustworthy AI in the OECD AI Recommendation (May 2019). National policies are needed to promote trustworthy AI systems and spur beneficial and fair outcomes for people and for the planet, especially in promising areas underserved by market-driven investments. The creation of an enabling policy environment for trustworthy AI includes, among other things, facilitating public and private investment in AI research and development and equipping people with the skills necessary to succeed as work evolves (Box 1).

Public sector commitment

The implementation of emerging technologies would need new mindsets, leadership and skills in the public sector to secure commitment to sustainable and inclusive digital transformation. To this end, three specific factors appear most essential: cultural commitment to change, political support, and solid legal and regulatory framework to address uncertainties and policy gaps.

Cultural commitment

Today, digital transformation involving emerging technologies such as AI and blockchain is likely to implicate many processes and systems and affect the functions, expectations upon and role of government in societies that are constantly evolving. Many governments are shifting focus to a more strategic and systematic approach to digital. They are **stepping up understanding** of the potential value of using emerging technologies to fulfil their mandate and public expectations and keeping abreast with the scale, complexity and speed of digital transformation occurring across all segments of the economy. Acquiring **adequate knowledge and skills** will be one of the core actions in creating a pool of dedicated civil servants and experts, capable of identifying appropriate technologies for rethinking and innovating a given task, purpose or need.

Incentive change will play a fundamental role in nurturing cultural commitment to continuous improvements and "outside of the box" thinking in the public sector. There needs to be a cultural shift at all levels of governments in being comfortable with (reasonable level of) uncertainty arising from the use of emerging technologies and recognising the value of trial-and-error. This will require efforts on two fronts: first, a new system of adequate incentives to encourage public administration leaders and staff to engage in learning-by-doing, for which failures are valued as much as successes. This implies that human resources departments will need to be more strategic and integrate experiments and initiative-taking in staff performance evaluation and promotion. Second, experiments should follow a set of pre-established, well-thought methods or principles, and a fine balance needs to be sought between risk-taking and early-stage innovation on the one hand, and stability, predictability and value-for-money on the other.

Political support

The recognition from the political leadership of ETs being an important asset to support the digitalization of the public sector is essential. A pro-active engagement of governments, parliaments and top-officials within the public sector towards ET adoption is fundamental to also set long-term strategies that define the vision and identify the infrastructure and assets needed to support innovation in public services enabled by ET. Political support is also necessary to enforce long-term actions to fostereducation and research in ET as well to create a prolific ecosystem for start-ups and private sector to offer adequate ET-based services and solutions to the public sector

As previously highlighted, **pragmatic and calculated risk-taking** can help gain political support when governments and public sector organisations experiment with emerging technologies. This is best illustrated in the procurement of digital technologies: large-scale high-risk projects can be separated from smaller ones that can go to younger players to encourage broader-based innovation and diversify the pool of solution providers; while less risk adverse areas can be differentiated from others where the best decision for a public agency is to be a market follower to ensure value for money. In addition, more freedom can be given to experimenting with new ideas and practices at the local level first before upgrading to the national level in case of successful outcomes.

As emerging technologies are likely to redefine, partially if not integrally, the organisation's main goals, roles and functions, political support for public sector adoption of new technologies will need to be translated into **new working methods, practices and structures**. Flexibility in certain administrative procedures and rules can be considered to allow quicker feedback and more agile design thinking approaches, and a pilot can start small and focused in order to control political risk exposure and reduce administrative cost

in case of failure. As data is the fuel of digital transformation and the infrastructure needed for a fruitful use of AI and blockchain, an **adequate data governance**, which facilitates data availability, interoperability, quality, accessibility and sharing, will be a critical factor for reaping full benefits of the technologies (OECD, 2018[24]).

For example in 2017, the Australian Productivity Commission's Data Availability and Use Inquiry found significant barriers to effective data sharing by Australian Government agencies. In 2018 and in response to the Inquiry, the Australian Government announced a $65 million investment for a suite of reforms to improve the way data is accessed, shared and released, and improve safeguards for data. This suite of reforms includes:

- introducing a Consumer Data Right to give Australians greater access and control over their data, empowering them to be able to get a better deal from their bank, energy and telecommunications companies;
- establishing a National Data Commissioner to improve how the Australian Government manages and uses data;
- establishing a National Data Advisory Council to advise the National Data Commissioner on ethical data use and technical issues;
- introducing Data Sharing and Release legislation to improve the use and reuse of public sector data, while strengthening the security and privacy protections for personal and sensitive data; and continuing to engage widely with the community on the data governance and stewardship issues.

Similarly, the UK is developing its National Data Strategy, which it expects to publish in 2020. In 2018, the UK created the Centre for Data Ethics and Innovation, housed under DCMS. This is an independent body advising the UK Government on the benefits & risks of AI and data-driven technology. Its brief covers (1) analysing and anticipating risks and opportunities such as gaps in governance and regulation that could impede the ethical and innovative deployment of data and AI; (2) agreeing and articulating best practice such as codes of conduct and standards that can guide ethical and innovative uses of AI; and (3) advising government on the need for action including specific policy or regulatory actions required to address or prevent barriers to innovative and ethical uses of data. GDS and the Office for AI worked with the Alan Turing Institute - the UK's national institute for data science and artificial intelligence - to develop new guidance, Understanding Artificial Intelligence Ethics and Safety

Governments should consider the need for a rounded 360° data vision, a holistic view to guarantee public agencies the use of data in the context of AI and Blockchain. Not only working on a Data Strategy for adopting a data-driven government but also in establishing principles that settles the fundamental basses. A whole-of-government approach for the development of this data strategy, establishing a common view on data collection, management, governance, and use, with the aim of improving service delivery, better informing decision-making, enhancing operations, and fostering trust through privacy, transparency and accountability.

Data is the central asset in everything that government oversees and provides. The ability to leverage that data strategically, in real time, will drive data-based decision making and will enable step-level change in government's ability to seamlessly deliver services.

Furthermore, governments should consider the governance and organisational impacts of blockchain implementations, given their fundamental differences with traditional centralised information infrastructures (Allessie *et al*., 2019). To fully harness the potential

of blockchain in the public sector, **administrative processes and governmental structures** may need to be re-engineered to adapt to the technology and not the other way around (Allessie *et al*., 2019).

Sound regulatory framework

Regulation offers important opportunities for governments to capitalise on the benefits while mitigating the risks brought by digitalisation. Governments are using **legal and regulatory instruments** to provide guidance to facilitate the use of emerging technologies in different departments[14], or to support their use in specific policy areas[15].

It is however important to emphasise the **regulation of process and outcome** over regulation of system. Regulations that are technologically deterministic might get stuck rather than be able to flex with the fast pace of technological changes we currently see. Building on previous discussions undertaken within the OECD Regulatory Policy Committee, a new set of guidance will soon be proposed to support governments in choosing among the range of regulatory and alternative approaches to promote digital innovation and reduce risks (OECD, 2019d).

Partner engagement – maximise synergies through public-private collaboration

Governments and public sector organisations should partner with the private sector to leverage industry progress in advanced digital technologies and support open innovation. Countries like Chile, Panama and Latvia have been promoting public-private collaboration through a series of Memorandums of Understanding (MoU), to implement pilot experiences in the application of Big Data, Cloud Computing and AI. Estonia has aimed to offer new ways to co-operate with the private sector, such as by organising deep-dive events[16] or by offering "sandbox" environment for technology companies to work on existing applications and solutions. Italy launched a dedicated platform for innovative procurement, supporting the development of new solutions able to satisfy the «smart needs», identified by the Italian Digital Strategy. The new approach is expected to generate a positive impact on the public sector as system and bring the development of technological solutions that can be replicated in other public and private contexts, with additional economic repercussions that can contribute to accelerating entrepreneurial growth in the Country. Korea is shifting from essentially focusing on financial provision for technological developments, to providing support in a more comprehensive way, through which it can bolster technology, data, infrastructure, expansion and legal improvements altogether. The Korean government is also working to establish an ecosystem where the public sector supports private market formulation, with the aim of maximising the latter's innovation capacity.

[14] For instance, in Canada, the Treasury Board Policy Suite is using a series of quasi-legal, often binding policy instruments that provide best practice direction to departments. Finland prepared a study of algorithms as decision-makers and the possibilities and challenges of artificial intelligence in the Finnish national regulatory environment.

[15] In Finland, the Government resolutions on data and robotics were given in late May and early June 2017 to support development of intelligent transport services, information security, robotics and big data.

[16] At the end of the year 2018, Estonia held its first e-Government hackathon in Tallinn together with Garage 48, a start-up hackathon series. It is planning to go on with hackathons also in 2019, expecting to have around four hackathons per year.

4.3. Questions for further work and guidance

This working paper has tried to capture the current state of art on the public sector adoption of emerging digital technologies, with a specific focus on AI and blockchain. It raised the attention on some of the associated challenges and opportunities currently facing governments and public sector organisations. The key assessments are derived from the first round of data gathering and analysis conducted on the 20 TG countries since January 2018. At the time of this writing, more initiatives than the ones presented in the paper are being implemented or developed in several countries among the TG. Given that governments are still at an early stage of using some of these emerging technologies, a permanent mapping exercise will be helpful to better evaluate the public sector adoption trends, identify replicable good practices, create synergies and foster experience sharing among a wider range of OECD member and partner countries.

Building on the main findings of the work completed so far by the E-leaders' TG, further experiments and analysis are required to resolve some of the challenges encountered in the use of emerging technologies in public sector, as highlighted in the relevant sections above, and be able to ground on experience concrete guidance. Practically speaking, the following checklist could be used in the development of such guidance:

What actions are needed to strengthen the following enablers for public sector adoption of emerging technologies?

- Securing political support;
- Securing private sector commitment;
- Promoting public awareness;
- Fostering a dynamic academic environment;
- Creating synergies with innovation centres and labs;
- Nurturing and providing incentives for creativity of the public servants, and building up digital competencies in public administration as a key step towards digital mature organisations;
- Supporting start-ups and private sector initiatives to bring value to the public sector;
- Participating in the international debate.

What actions are needed to help address the following constraints?

- Lack of common standards;
- Unsuitable legal framework;
- Lack of specific competences in the public sector;
- General low understanding of ET and low digital literacy across the population;
- Limited understanding of the role of the ecosystem including actors outside the government;
- Creation and fostering of synergies with the academia and the private sector;

- Establishment of a flexible governance model able to ensure a whole-of-government approach and the right level of control over the adoption of these potentially transformative technologies in the public sector.
- The OECD is currently developing practical guidance on the AI Recommendation, to guide governments in its implementation, including in those areas related to adoption in the public sector.

More generally, future efforts and analysis could for example aim at assisting governments' efforts in line with the point below:

- First of all, the **efficiency of public investments** should be continuously monitored to provide more evidence-based indication on the effective levels and forms of public support for technological development and adoption. This will also be useful to enable governments in presenting sound business cases – or value propositions – when investing in ET.
- Second, there should be further assessment of the design and appropriate mix of **regulatory approaches** – including soft and hard regulatory instruments – on the public sector adoption of emerging digital technologies and their associated social, ethical and legal implications. For instance, many governments are taking steps to revisit their regulatory frameworks to address key concerns of fairness, transparency, privacy and accountability arising from the use of AI. So far, the main focus has been on regulation in the digital economy; in the future, more attention should be given to regulation of its use within governments and public sector organisations, which may require a finer understanding of the distinct features, needs and challenges of public sector users.
- Third, a comparison of different **models of co-design and co-delivery arrangements** will help governments appraise the advantages and limitations of each approach and find the right combination of public, private and social efforts in the design and implementation of innovative services. In particular, as governments embrace emerging technologies, where does it start in order to make sure they are capably equipped to be both a sophisticated consumer and user, and an effective regulator and overseer? While governments will need to establish good working relationships with the private sector, how does that work in practice? Where to draw the balance between increasing internal absorptive capacity, *i.e.* public sector ability to understand and capture opportunities and steer changes, and outsourcing substantial amounts of digital interventions to the private sector, remains one of the most significant challenges in transitioning from e-government to digital government practices. Part of the answers may come from how governments are adapting governance mechanisms (*e.g.* institutional setups) to properly lead, coordinate, promote and monitor the adoption of emerging technologies in the public sector.
- Finally, there needs to be a comprehensive analysis of the implications and pros and cons of blockchain applications in the public sector, as well as their genuine impact on improving participatory and collaborative democracy. The **role of State and centralised institutions** in a hyper-digitised economy and society will need to be revisited, and new forms of democratic participation may emerge to address the limitations of nation-states and today's digital monopolies. To varying degrees, blockchain-based decentralised governance poses challenges to the traditional constructs of State authority, citizenship and democracy (Atzori, 2017). While

many enthusiasts simply promote blockchain as a more efficient and trustworthy instrument to increase citizens' ownership over democratic processes, techno-libertarians openly encourage the use of blockchain to empower bottom-up, self-governed community against the very concept of authority. Against the backdrop of strong public dissent against institutions, there may be merit in reducing concentration or abuse of power with distributed technologies, but to what extent it is possible to decentralise public administration through blockchain, which parts of government services are possible and desirable to be managed through permissionless networks, and to what extent blockchains and decentralised platforms can indeed manage political interactions on large scale (Atzori, 2017)? All these questions warrant further carefully designed experiments and open consultations with citizens and the civil society.

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Annex A. Background Information on the OECD Thematic Groups

Role, mandate and purpose of the OECD Thematic Groups

The Thematic Groups of the OECD Working Party of Senior Digital Government Officials (E-Leaders) of the Public Governance Committee adopt an empirical approach to look into concrete cases of application and implementation (i.e. existing projects and experiments implemented or foreseen across OECD member countries) to identify key policy actions for governments in priority areas selected by the delegates. This work responds to the request of the adherent countries to the OECD Recommendation on Digital Government Strategies to complement the Recommendation with specific guidance in priority areas for the member countries.

The Thematic Group on Emerging Technologies (AI & blockchain)

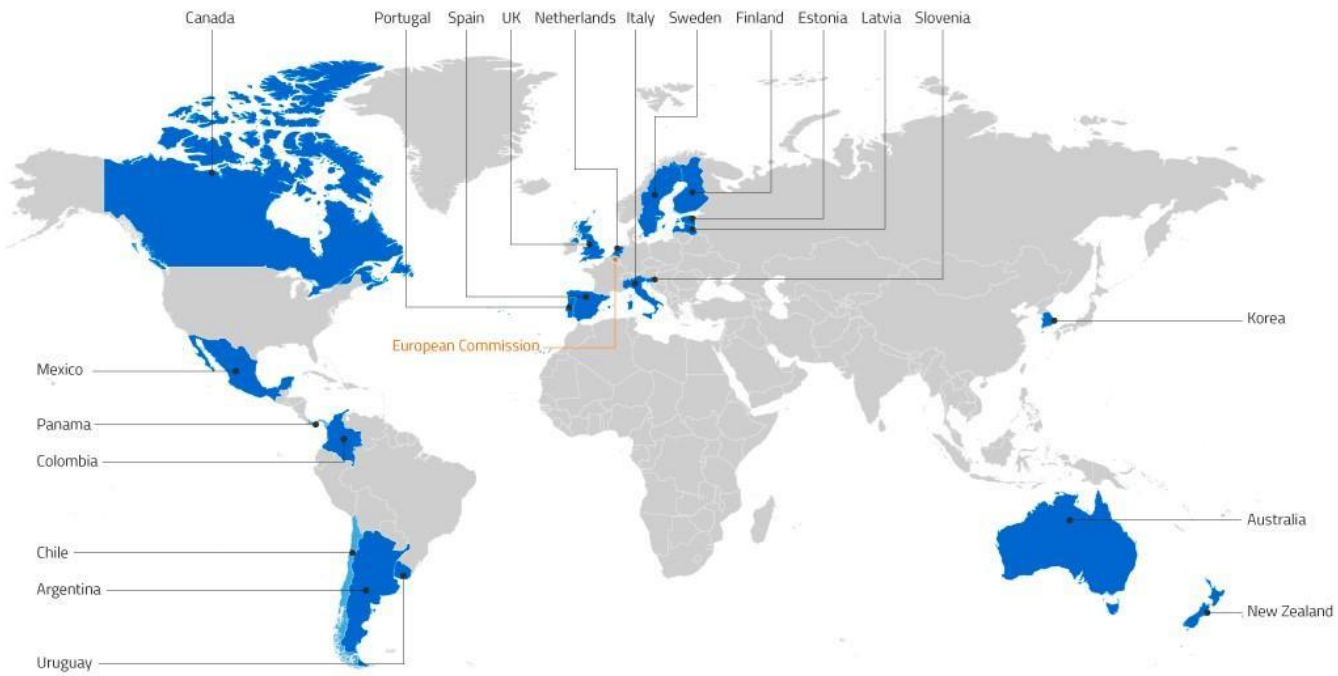
For few years the OECD Working Party of Senior Digital Government Officials (E-Leaders) has been discussing the main opportunities and challenges associated with the increasing uptake of emerging technologies across the public sector, as part of the broader digital transformation efforts. The Thematic Group on Emerging Technologies (focused mainly on Artificial Intelligence and blockchain) of the E-Leaders is a direct follow-up to the 2017 meeting in Lisbon, where delegates recognised the need to better understand this trend in order to be able to go beyond the hype and gauge the real value of emerging technologies for the public sector. 20 countries are actively participating in the TG activities and are collaborating with the Secretariat.

In line with the above, the Thematic Group on Emerging Technologies has the following objectives:

- Map the current use of emerging technologies in the public sector across OECD member and partner countries;
- Understand the implications, requirements and impacts of using emerging technologies to foster the digital transformation of the public sector and provide innovative solutions for public services;
- Analyse in particular the possible impact of ET use on citizens' wellbeing and the role of established ethical frameworks to improve citizens' trust;
- Exchange knowledge on existing practices, or on-going experiments, and related challenges faced by governments in the use of emerging technologies in the public sector worldwide to shed lights on "what works" and what "doesn't";
- Develop a set of guidelines to assist governments in advancing a meaningful, effective and sustainable use of emerging technologies across their public sectors.

As shown by the map below, the TG is composed of 18 OECD member countries, 2 non-member countries and the European Commission. Five countries contributed to the mapping without being involved in the preliminary phase of the work of the TG. These countries are: Australia, New Zealand, South Korea, Sweden, and the United Kingdom.

Participants of the TG



The large number of countries participating in the work of the TG allowed gaining a detailed picture of the opportunities and challenges linked to the use of ETs in the public sector. The potential of Artificial Intelligence for the public administrations is manifold.

The work of the TG is showing how the development of AI technologies has already an impact on the public sector and it is expected that the use of AI will play a growing role in the development of public policies itself.

Annex B. Questionnaire

State of the art on Emerging Technologies in your country - Questions

1. Could you, please, provide the Thematic Group with background information about Emerging Technologies (ET) overall context in your country? (E.g. the main political and institutional motivations; resistance - and reasons for this - among the stakeholders)
2. Does your government have a national strategy on ET?
    a. What are the key public sector actors involved in the implementation of your national strategy?
    b. What are the main milestones regarding the strategy implementation?
    c. What is the level of public investment in emerging technologies?
3. What kind of public ET solutions are available or being tested in your country?
4. Which policy levers and uptake policies are being applied in your country to foster the use of ET solutions in the Public Sector? (e.g. Legal and regulatory framework, funding mechanisms, cooperation with the private sector)
5. What are the major enablers and constraints for the implementation of ET solutions in your country? (E.g. level of digital literacy of the population; awareness and public promotion efforts; political support; systems of incentives; private sector and civil society involvement; existing legal frameworks)
6. How ET solutions are being used to better manage immigration, innovation in public procurement and crisis management issues in your country?
7. How are ET solutions being used to improve the productivity agenda of your country? (E.g. Productivity at private and public sectors, reducing bureaucracy, reducing marginal costs of eServices)
8. How does the Public Sector integrate ET solutions in its services? (Public Procurement regulations? Direct investment? R&D projects?)
9. Do businesses interested in implementing ET projects have access to capital and favourable financing options?

Annex C. List of emerging technologies

Defining which technologies are truly "emerging" is difficult because so few of the usual metrics – journal citations, number of researchers in a new field, budgets and products on the market – are readily available. Moreover, many emerging technologies are defined less by the parameters of a particular field (biology, physics, etc.) than by the global challenges they seek to address (the search for new sources of clean energy, the effort to deal with Alzheimer's disease and dementia in an ageing society, the provision of safe drinking water, etc.*)* (OECD Policies for emerging technologies).

By emerging technologies, the participants of the TG mean the ones that, even if not enlisted as frontier technologies, might be able to produce innovative solutions for public services, as to reflect the objectives of the Thematic Group. We have provided to list the ones that we were so far able to map and that we think are able to provide innovation in the delivery of public services. Please, note that the definitions provided in the document do not intend to be exhaustive or static.

Transparently Immersive Experiences

- **Augmented reality**: is the real-time use of information in the form of text, graphics, audio and other virtual enhancements integrated with real-world objects. AR integrates and adds value to the user's interaction with the real world, versus a simulation;
- **Connected home**: it is networked to enable the interconnection and interoperability of multiple devices, services and apps, ranging from communications and entertainment to healthcare, security and home automation. These services and apps are delivered over multiple interlinked and integrated devices, sensors, tools and platforms. Connected, real-time, smart and contextual experiences are provided for the household inhabitants, and individuals are enabled to control and monitor the home remotely as well as within it;
- **Brain-Computer Interface**;
- **Artificial body parts, exoskeletons**;
- **Nanotechnology**: is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers. Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering;
- **3D printing:** new industry where a lot of consumer goods, spare parts or even cars and houses can be printed**;**
- **4D printing**. A new design of complex self-evolving structures that vary over time due to environmental interaction;
- **Graphene and new materials:** materials with new features;
- **Virtual reality**: provides a computer-generated 3D environment that surrounds a user and responds to that individual's actions in a natural way, usually through

immersive head-mounted displays and head tracking. Tracking and haptic controllers and feedback devices may be used as well[17];

Digital Platforms

- **5G**: is the term used to refer to the next (fifth) generation of ubiquitous mobile telecommunications technology. No official definitions of 5G exist[18];
- **Edge Computing**: is a method of optimising cloud computing systems by performing data processing at the edge of the network, near the source of data. This reduces the communications bandwidth needed between sensors and the central datacentre by performing analytics and knowledge generation at or near the source of the data;
- **Distributed ledger technology (DLT)**: is a consensus of replicated, shared, and synchronized digital data geographically spread across multiple sites, countries, or institutions. There is no central administrator or centralised data storage. A peer-to-peer network is required as well as consensus algorithms to ensure replication across nodes is undertaken; **Blockchain is one of the most common implementation of DLT**[19];
- **Smart contracts**: is a computer protocol intended to digitally facilitate, verify, or enforce the negotiation or performance of a contract;
- **Global cryptocurrencies, local crypto currencies, programmable money, crypto KYC regulation**;
- **IoT Platform**: platform on which to create and manage applications, to run analytics, and to store and secure your data in order to get value from the Internet of Things (IoT)[20];
- **Software-Defined Security**: software-defined security (SDS) is a type of security model in which the information security in a computing environment is implemented, controlled and managed by security software[21];
- **Li-Fi:** technology for wireless communication between devices using light to transmit data.

[17] https://www.gartner.com/it-glossary/ (accessed on 21 February 2019)

[18] EUROPARL (accessed on 21 February 2019)

[19] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492972/gs-16-1-distributed-ledger-technology.pdf (accessed on 21 February 2019)

[20] https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/making-sense-of-internet-of-things-platforms (accessed on 21 February 2019)

[21] https://www.techopedia.com/definition/29942/software-defined-security-sds (accessed on 21 February 2019)

AI solutions

- **Virtual Assistants** (Chat bots or Voice bots): conversational, computer-generated characters that simulate a conversation to deliver voice- or text-based information to a user via a Web, kiosk or mobile interface. A VA incorporates natural-language processing, dialogue control, domain knowledge and a visual appearance (such as photos or animation) that changes according to the content and context of the dialogue. The primary interaction methods are text-to-text, text-to-speech, speech-to-text and speech-to-speech[22];
- **Speech Recognition**: systems interpret human speech and translate it into text or commands. Primary applications are self-service and call routing for contact center applications; converting speech to text for desktop text entry, form filling or voice mail transcription; and user interface control and content navigation for use on mobile devices, PCs and in-car systems. Control of consumer appliances (such as TVs) and toys is also commercially available but not widely used[23];
- **Natural Language Generation:** Natural Language Generation (NLG), a subfield of artificial intelligence (AI) which produces language as output on the basis of data input. Whereas NLP is focused on deriving analytic insights from textual data, NLG is used to synthesize textual content by combining analytic output with contextualized narratives[24];
- **Natural language processing**: technology involves the ability to turn text or audio speech into encoded, structured information, based on an appropriate ontology. The structured data may be used simply to classify a document, as in "this report describes a laparoscopic cholecystectomy," or it may be used to identify findings, procedures, medications, allergies and participants[25];
- **Biometrics:** enable more natural interactions between humans and machines, including but not limited to image and touch recognition, speech, and body language[26];
- **Computer vision**: is an interdisciplinary field that deals with how computers can be made for gaining high-level understanding from digital images or videos. From the perspective of engineering, it seeks to automate tasks that the human visual system can do;
- **Machine Learning**: the goal is to devise learning algorithms that do the learning automatically without human intervention or assistance[27];

[22] ibid. 38

[23] ibid. 38

[24] https://narrativescience.com/Resources/Resource-Library/Article-Detail-Page/what-is-natural-language-generation (accessed on 21 February 2019)

[25] ibid. 38

[26] https://www.forbes.com/sites/gilpress/2017/01/23/top-10-hot-artificial-intelligence-ai-technologies/#58eaa8b71928 (accessed on 21 February 2019)

[27] https://www.cs.princeton.edu/courses/archive/spr08/cos511/scribe_notes/0204.pdf (accessed on 21 February 2019)

- **Deep Learning**: allows computational models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction**;**
- **Swarm Intelligence**: is the collective behaviour of decentralized, self-organized systems, natural or artificial. SI systems consist typically of a population of simple agents or boids interacting locally with one another and with their environment;
- **Robotics:** deals with the design, construction, operation, and use of robots, as well as computer systems for their control, sensory feedback, and information processing**;**
- **Recommender systems**: subclass of information filtering system that seeks to predict the "rating" or "preference" that a user would give to an item;
- **Expert systems**: is a computer system that emulates the decision-making ability of a human expert;
- **Affective computing**: systems and devices that can recognize, interpret, process, and simulate human affects;
- **Intelligent decision support systems**: is a decision support system that makes extensive use of artificial intelligence (AI) techniques;
- **Digital twin**: refers to a digital replica of physical assets, processes and systems that can be used for various purposes. The digital representation provides both the elements and the dynamics of how an Internet of Things device operates and lives throughout its life cycle. Digital twins integrate artificial intelligence, machine learning and software analytics with data to create living digital simulation models that update and change as their physical counterparts change.

Other ET Solutions

- **Autonomous vehicles**: are vehicles that are capable of sensing their environment and navigating without human input;
- **Quantum computing**, quantum cryptography, quantum communication;
- **Collective Adaptive Systems**: Development of hybrid systems where people and machines work together by implementing each other;
- **Future use of DNA sequencing**;
- **Outside body (laboratory) grown organs**;
- **Space technology**: new innovative satellite systems, micro satellites...**;**
- **Commercial UAVs (Drones)**: An unmanned aerial vehicle (UAV), commonly known as a drone, is an aircraft without a human pilot aboard;
- **Bionics:** biological methods and systems found in nature to study and design of engineering systems and modern technology;
- **Information warfare;**
- **Enhanced human;**
- **Fusion power.**