INSTITUTE FOR INNOVATION
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Digital public infrastructure and public value:
What is 'public' about DPI?

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1. Introduction

Society is currently at a crucial turning point in how it perceives the potential of digital technologies. For decades, digital transformation was associated with digitising public and private services, developing software and platforms to solve specific needs, and using data to make better decisions. Some companies made substantial profits from the new technologies and business models that emerged – hence Big Tech – but the perspective on digital is expanding. Instead of focusing on products, specific technologies or digital services, attention has been directed at deeper layers, i.e. the railways of a digital economy and operating 21st-century societies.

For 10,000 years, public physical infrastructure has been fundamental to economic and social development. Roads, electricity, water and plumbing all became public infrastructure because they were essential to the functioning of society. In the 21st century, societies run on software. Digital systems that coordinate vaccine distribution, provision social welfare, manage identity records, make payments and share medical data are no longer optional, they are critical infrastructure. At this moment, new digital societal structures and capabilities, such as digital public infrastructure (DPI), are not just being regulated, but funded and created by governments, philanthropies, transnational organisations and the private sector. However, these transformations are not neutral; they have a direction. **This paper addresses how to ensure that DPI is not only regulated, but created and governed for the common good by maximising public value creation**.

DPI officially entered the global policy lexicon in 2023. This is a fact best encapsulated by the G20 Digital Economy Working Group, which published a rare consensual joint statement in August of that year outlining the relevance of DPI in fostering inclusive economies and meeting the Sustainable Development Goals (SDGs)[7]. Although there is yet to be a single definition for DPI, there is a consensus around it being reusable digital components that enable public benefits at a societal scale. Three types of DPI are widely recognised – digital ID, payments and data exchange systems –, and sectoral DPI are also emerging.

Early evidence that DPI may provide a much-needed boost to fulfil SDG commitments and foster financial inclusion has particularly piqued the interest of governments, and international and civil society organisations. One example is the Unified Payments Interface (UPI), the digital payment protocol created by the Indian government. Through interoperability and by providing a neutral platform for anyone across the payment ecosystem, UPI has brought down the costs of digital transactions and made the provision of financial services more accessible for hundreds of millions of people. Today, street vendors can even sell 10-cent cups of chai using UPI-enabled payment systems connected to speakers that orally confirm the transaction for the illiterate (Parkin 2023). Similar transformations are expected in other policy areas. The UNDP (2023) estimates that by 2030, a DPI approach could lead to a 20-33% potential growth acceleration through financial DPI, a circa 4% carbon emissions reduction through carbon trading DPI, and a 28-42% increase in access to justice as DPI facilitates faster case management and reliable open dispute resolution (ODR).

7 The final statement is available at: https://g7g20-documents.org/database/document/2023-g20-india-sherpa-track-digital-economy-ministers-ministers-language-g20-digital-economy-ministers-meeting-outcome-document-an (Accessed: 22 November 2023).

Despite the growing practice-oriented literature and vast number of countries implementing DPI in the past decade, DPI is still emerging in the scholarship domain. The earliest frameworks, measures and narratives – mainly originated in the policy space – have still been unable to capture the broader 'public' and 'common' value of DPI. Meanwhile, the scholarship on the digital transformation of the public sector has primarily focused on the digitisation of public services and efficiency gains enabled by technology (Meijer and Bekkers 2015; Mergel, Edelmann and Haug 2019), although there has been an increasing acknowledgement of the importance of embedding the notions of public value in technological solutions for the public sector (Bannister and Connolly 2014; Bonina and Cordella 2009 2012; Mazzucato, Entsminger and Kattel 2020).

The increased interest in DPI and its potential for societal impact raises profound questions about how 'public' is understood. The definition of 'public' in DPI cannot be assumed to be neutral. It is embedded with values, assumptions and directions of impact created by the infrastructure. For example, Eaves and Sandman (2023) argue that publicness derives from guaranteeing the essential capabilities required to participate in a digital society. However, other definitions of publicness emphasise different attributes, such as openness or social value (Zuckerman 2020; Center for Digital Public Infrastructure 2023). Articulating a clear reference to identify how organisations frame the public value created by DPI is pressing. There has already been a marked increase among multinational funders and national governments in public policies, investments and attention directed at DPI as part of the policy agenda. The varied framings of publicness must be unpacked to understand how DPI creates value and to support the DPI ecosystemic players in designing and implementing more effective DPI.

Therefore, this paper aims to contribute to the gap in the literature on DPI by clarifying a fundamental question: what makes DPI *public*? The goal is to understand what values have been associated with DPI and how to maximise DPI's public value creation potential.

This paper reviews the literature on traditional infrastructure to reflect on how debates on public value have shaped scholars' understanding of public infrastructure more generally. Two high-level frames for value creation are identified and applied to the DPI context: attributes and functional perspectives. We argue that 'publicness' in DPI goes beyond a broad **'public interest'** notion and implies normative assumptions, i.e. **public values**. These should be made explicit. We then argue that the conceptual lens of the **'common good'** (as developed recently in Mazzucato 2023) is more aligned with a public value maximisation perspective than the vague notion of 'public interest', adequately capturing the role of government as shaping markets and setting collective goals in the DPI space. **This paper discusses how a theory of the 'common good' might help strengthen the public value creation process and inform the governance of emergent DPI.** This paper does not intend to engage in the definitional debate over DPI, though shedding light on what *public* means might help clarify the origins of the distinct visions behind the concept of DPI.

The paper proceeds as follows: the second section outlines the paper's key concepts: traditional and digital-era infrastructure; the third section synthesises the literature on the public value generated by digital transformation processes, such as e-services to government-as-a-platform (GaaP), that preceded DPI; the fourth section discusses the contested nature of publicness in DPI, identifying different arguments for public value creation associated with the features and functions of digital infrastructures by comparing them with traditional infrastructure; the fifth section introduces the notion of 'common good' and its relevance for the governance of DPI; and finally, the conclusion encompasses a summary and suggestions for further research. But first, back to basics: What is meant by infrastructure and digital infrastructure, and what makes them public?

2. Back to basics: from traditional to digital infrastructure

2.1 What is infrastructure?

Given its ubiquitous use in policy and technology circles, the term infrastructure is surprisingly contested. The etymology of 'infrastructure' derives from Latin, meaning 'underneath the structure. French engineers began using the term in the 19th century to describe physical structures, such as excavations, earthworks, tunnels and bridges, that were supportive of or literally below railways, water tanks and other 'superstructures'[8]. The military adopted and popularised the term in the 1950s during the Cold War, albeit not without some controversy. Borrowing the term from his French counterparts, US President Eisenhower used it to justify building military installations (infrastructure) that could 'support' (the superstructure of) NATO's shared capabilities. Subtly, the notion of infrastructure was expanded beyond its literal meaning of 'underneath the structure' to incorporate a vaguer, but essential, idea of collective use.

Today, the idea of infrastructure has broadened to social, institutional, digital and other categories, although most dictionary definitions of infrastructure are inspired by the notion of *physical* infrastructure. For example, the Oxford Dictionary defines infrastructure as, 'The basic physical and organisational structures and facilities (e.g. buildings, roads, power supplies) needed for the operation of a society or enterprise,' while the Cambridge Dictionary defines it as, 'The basic systems and services, such as transportation and power supplies, that a country or organisation uses in order to work effectively.'

Frischmann's functional definition of infrastructure (2012) as 'shared means to many ends' is a valuable starting point for two reasons. First, it is holistic in that it groups any infrastructure – not only physical but also social, institutional, and digital. Second, it emphasises elements we consider essential in the analysis of any infrastructure: communal use ("shared means") and the numerous possibilities of use ("to many ends"). According to Frischmann (2012), infrastructure should satisfy three criteria:

- The resource must be consumed non-rivalrously for an appreciable range of demand.
- Social demand for the resource is driven primarily by downstream productive activities that require the resource as an input.
- The resource may be used as an input into a wide range of goods and services, which may include private goods, public goods and social goods.

The first criterion reflects the **'shareable'** nature of infrastructural resources, i.e. they are not always pure public goods, because if demand is too high, the resource might not accommodate the required capacity. For example, roads can be used by anyone, but cannot accommodate all cars worldwide. In the digital domain, if using digital infrastructure (see 2.2) relies on

8 See Carse (2016) for a historical review of the term.

limited storage or processing power, then it is an impure public good[9]. The second criterion is associated with the notion of infrastructure being **'means'**: i.e. in economic terms, capital goods or intermediate capital resources. Finally, the third emphasises the genericness of purpose, i.e. that infrastructures are used **'to many ends'**, which can be services and other goods. In the rest of this paper, this definition of infrastructure is used.

2.2 What does infrastructure mean in the digital domain?

Put simply, infrastructures in the digital domain are digital resources, such as systems and specifications, built as shared means to many ends. In other words, digital resources are seen as infrastructure when different societal actors can leverage them for several possibilities.

When the term digital infrastructure is used, many still associate it with the physical telecommunications infrastructures that enable the digital era: internet cables, data centres and transmission networks. Others associate it with the internet. The internet is the most prominent example of how software (instructions, protocols), combined with hardware (computers, cables), can be digital infrastructure. As long as they have access to a device and a good connection, any person, business or entity can use the internet to conduct research, connect with other people, engage in commerce, play games and do innumerable other activities. While the governance of this infrastructure is both contested and evolving, there is a broad consensus that both the pipes and protocols of the internet are a form of infrastructure. The internet is a 'shared means to many ends'.

This paper does not focus on internet protocols and the physical infrastructures that support them. Instead, it focuses on an emerging layer of digital infrastructure that currently sits above the hardware and internet protocols layers, and is emerging as a new form of infrastructure essential to the operation of modern markets and society, such as digital IDs, payments and data exchange systems.

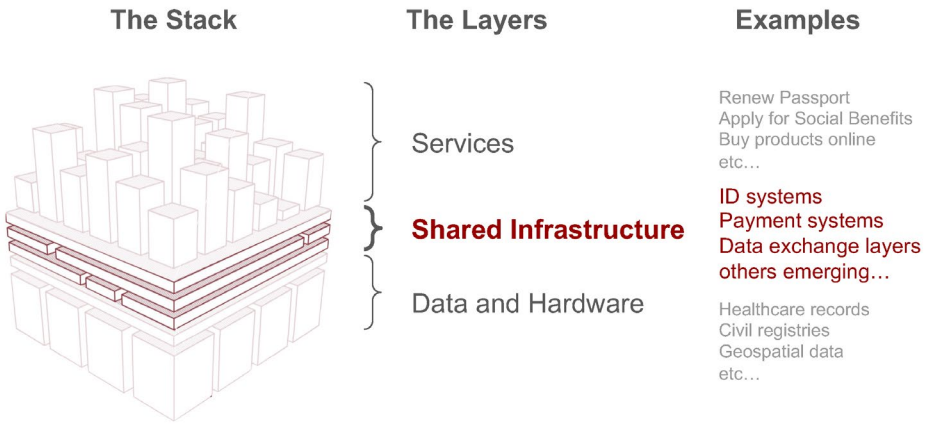
The literature on digital infrastructure dates to the early 2000s, when the terms information infrastructure (Hanseth and Lyytinen 2008; Hanseth and Lyytinen 2010) or e-infrastructure (Edwards et al. 2009) were used to describe infrastructures like the internet: networked, interoperable, heterogeneous[10]. For the sake of simplicity, this paper does not explore the technical definitions of digital infrastructure, but it is particularly useful to understand infrastructure as a digital stack (see Figure 1)[11]. In general terms, the logic of the stack is that each layer is xconxnected to the ones above and below, and the upper layers leverage the resources created in the layers below. The infrastructure layer provides the shared resources that connect the data and hardware layers to the multiple services and use cases that might emerge. Shared infrastructure can be provided both by public and private organisations or even co-developed by different institutions (see Table 1).

9 In economics, a public good, or 'pure' public good is characterised by two fundamental attributes: non-excludability and non-rivalry. A good is considered non-excludable when it is costly or impossible for one user to exclude others from using it. It is non-rivalrous when its consumption by one person does not reduce the amount available for others. In practice, very few goods are 'pure' public goods, as many are partially rivalrous or partially excludable. In this case, they are called 'impure' public goods.

10 In this literature, the terms digital platforms, digital infrastructure and digital architecture are not singularly defined. There are also many different types of digital architecture, such as service-oriented architecture (SOA) or microservices architecture, both following the layered and modular logic of digital innovation (Yoo et al. 2010).

11 The term digital stack was coined and disseminated in the software development domain, and it usually refers to 'a set of interconnected yet independent single-purpose technologies (...) that work together towards general purpose tasks' (D'Silva et al. 2019).

Figure 1. The ‘stack’ and its layers



Source: Adapted from David Eaves' course materials[1,2]

Table 1. Examples of digital infrastructures

Types of infrastructure	Provided by the private sector	Provided by the government
Identity systems as infrastructures	**Google and Apple authentication systems** Google and Apple IDs can be used to authenticate individuals for several purposes. It is possible, for example, to use these IDs to sign up on a series of websites and to authenticate many services, such as Apple and Google Pay. New applications being created on Android and iOS also offer the option of authentication through Google email, Facebook account or Apple ID.	**India's identity system (Aadhaar)** Aadhaar is India’s digital identity system, providing residents with a unique 12-digit identification number. Linked to biometric and demographic data, it serves as a secure and universal means of authentication, facilitating access to various government services and financial transactions, and fostering digital inclusion.
Payment systems as infrastructures	**Mastercard's payment infrastructure** Mastercard’s payments infrastructure is a global system that facilitates electronic transactions between financial institutions, merchants and cardholders. Operating its network, Mastercard ensures the secure and seamless flow of funds through authorisation, clearing and settlement processes.	**Brazil's instant payment system (Pix)** Built 100% in-house by the Brazilian Central Bank, Pix is an instant payment scheme that enables users – people, companies and governmental entities – to send or receive payment transfers in a few seconds at any time, including non-business days.

12 The stack image is adapted from David Eaves, Richard Pope and Ben McGuire (2019).

Data storage and exchange systems as infrastructures	**Amazon Web Services (AWS)** AWS offers vast computing power, storage options and scalable services, allowing businesses and individuals to build and deploy applications, store data and manage various IT resources flexibly and cost-effectively.	**European Union's Next Generation Cloud Infrastructure and Services IPCEI (Cloud IPCEI) – under development** IPCEI stands for 'important projects of common European interest' and the Cloud IPCEI represents a digital infrastructure initiative aimed at fostering the collaborative development and deployment of advanced cloud computing technologies across the European Union. It serves as a strategic framework for building the foundation of a robust and interconnected digital ecosystem.

Source: Authors' elaboration

3. The public value of digital systems: from e-government to DPI

The impact of digital technologies in the public sector has been primarily analysed under the term 'e-government'. The effect of e-government on organisations and their environment is still contested. Generally speaking, the focus has not been on creating new business models or on digital as a catalyst for transformational change in the public interest. Instead, this literature has focused on the digital potential to enhance the efficiency of existing services (see, for example, Cordella and Tempini 2015, Linders et al. 2018, Siddiquee 2016, and Meijer and Bekkers 2015). Terms like digitisation, digitalisation or digital transformation are used interchangeably in the literature (Mergel et al. 2019). Although bringing services online can make people's lives easier and improve efficiency in government operations, this view is limited to considering incremental improvements. As a result, it underplays technology and the government's role in creating other large-scale values.

One of the first to envision how technology could transform governments' structures and working practices was O'Reilly (2009), who developed the notion of government-as-a-platform (GaaP). Following this approach, Fishenden and Thompson (2013) proposed that governments could act as drivers of 'open architecture' rather than open government, i.e. that digital government ecosystems may be created by following standardised, platform-type behaviours. The GaaP approach is derived from the literature on shared information infrastructure. Yet, perhaps surprisingly, public administration literature has not yet engaged thoroughly with analysing the business models enabled by such shared digital infrastructures. Instead, the primary focus has more often been on the potential enabled by digital services or the front-end rather than on the deeper layers of shared infrastructure (Brown et al. 2017). In their study on the adoption of the GaaP approach by governments, Brown et al. (2017) argue that even the UK, which had strong notions of GaaP inspiring its digital government initiatives, focused extensively on digital services and little on shared infrastructure.

Nevertheless, moving beyond the digital services paradigm towards a societal-scale digital transformation requires an explicit intention to create public value and reconceptualise the state's role. A growing body of research has attempted to use the public value theory to analyse the benefits of ICT transformations (see, for example, Bannister and Connolly 2014; and Bonina and Cordella 2009, 2012). Cordella and Paletti (2019) were among the first to articulate clearly how the GaaP architecture can help public administration deliver public value better. Analysing the Italian case, they suggest that public value creation requires a stronger GaaP orchestration, pointing to a potential role for the state to play.

Building public-governed digital infrastructure might allow states to develop capabilities (Cingolani 2022) essential to running a 21st-century society (e.g. managing identity, payments and data exchange). Digital infrastructures create opportunities for new regulatory and operational mechanisms to fight structural inequalities and offer an alternative to value extraction by corporate or foreign actors (O'Reilly et al. 2023). Nevertheless, if the direction for change is not set with purpose or, worse, set with the wrong one, DPI – and other digital transformations at the population scale – can facilitate structural exclusion and other types of problems at scale across a society. Several examples depict the potential harms. India's Aadhaar has had several documented examples of exclusion, highlighting the risk of pairing IDs with access to welfare services (Totapally et al. 2019). Likewise, in Kenya, misrecognised IDs have barred migrants and refugees from essential social security programmes (Weitzberg 2020). **Therefore, these systems' governance and guardrails should be set to prevent the infrastructures from being misused while maximising public value creation.**

As more countries embark on strategies to build DPI, it is fundamental to understand what 'public' means in DPI and how a theory of the 'common good' can help strengthen public value creation.

4. Digital public infrastructure: what is public about it?

What makes a digital infrastructure public? Porteous (2023) asked a similar question and argued that so far, seeking clarity around the 'I' in DPI is more relevant than the terms digital and public, claiming that there is little to be gained now by restricting the latter two. This section argues why the 'P' is more relevant than it seems.

Most, though not all, advocates for DPI seem to believe that 'public' in DPI does not mean **government ownership** but **public interest or oversight**. For Bozeman (2002), the notion of 'public interest' has historically been too vague and lacking in content to be helpful. The same might be said about DPI. By accepting that 'public interest' can be loosely defined, actors in the DPI space have struggled to find consensus in debates about what makes a digital infrastructure *public*. For example, one can argue that Mastercard, Visa and American Express payment infrastructures are DPI because their existence allows millions of people to use a credit function, generating a societal benefit, as can be argued for most digital infrastructures. These companies may also claim they are regulated, so government oversight exists. Ultimately, it becomes hard to differentiate between a digital infrastructure and a DPI; therefore, unpacking the 'P' in DPI matters.

However, in practice, each organisation in the DPI space has an implicit interpretation of public interest that is not vague or neutral, but rather has implicit normative values embedded in it. For Bozeman (2007), whereas the **public interest** is an ideal to be pursued but not tied to any specific content, **public values** have content and, in many cases, can be easily identified, measured and evaluated. He adds that 'public values' provide a *normative consensus* about '(a) the rights, benefits and prerogatives to which citizens should (and should not) be entitled; (b) the obligations of citizens to society, the state and one another; and (c) the principles on which governments and policies should be based.'[7]

How roads, streets and cities are designed affects what happens on them (Hillier and Hanson 1984; Hillier 1996). Like traditional infrastructure, DPI also has a direction. Although the question about publicness might seem like a minor semantic issue, this section exemplifies that different understandings of DPI embed normative perspectives. The assumptions that are driving the direction should be made explicit. To design and implement DPI with the public interest in mind, having a clear reference to identify how organisations frame and embed values in their decisions about DPI, is essential. This is the goal of this section.

4.1 The two ways of framing the 'publicness' of DPI

In many ways, the discussion around the publicness of DPI mimics the debates over traditional infrastructure. There are **two dominant ways of framing** the public benefits generated by traditional infrastructure (see, for example, Buhr 2003 and Frischmann 2012) that could be applied to DPI (see Table 2): by **attributes** and **functions** of the infrastructure.

In the DPI context, some groups focus on the benefits enabled by the digital infrastructure's **technical attributes**, such as being built with open standards or reusable building blocks (see section 4.1.1). The technical attributes are embedded in a **normative paradigm that values dynamic efficiency and scalability.** The second framing stems from a **functional** view of infrastructure, which understands societal benefits through the different societal purposes it achieves. For example, Eaves and Sandman (2023) define DPI as 'society-wide, digital capabilities essential to participation in society and markets as a citizen, entrepreneur and consumer in a digital era.' Another functional example comes from Zuckerman (2020), who emphasises the role of DPI in enabling civic life in digital spaces. Although there can be several functional perspectives, in this paper we focus on the most pronounced. The functional perspectives are **more directly associated with normative values, such as social value, economic value, capabilities, human rights and essential needs.**

7 An expanded notion of public value (Mazzucato and Ryan-Collins 2022) and the common good (Mazzucato 2023) is elaborated in section 5.

Table 2. Different ways of framing 'publicness' in DPI

	Framings for publicness	Implicit normative values	Mechanisms for value creation
Attributes	Be interoperable through open standards	Dynamic efficiency and scale	Open and interoperable standards prevent lock-in, and thus improve and increase and shape competition
	Be built using reusable building blocks	Dynamic efficiency and scale	The more digital infrastructure can be reusable, the higher network effects and combinatorial innovation
	Be built using open-source licenses (or be unlicensed and in the public domain)	Efficiency and scale	Digital infrastructure with open-source licenses or in the public domain generates positive externalities through adoptability, adaptability and prevention of lock-in
Functions	Foster community and social relationships	Social value	DPI resources in the context of social infrastructure can foster inter- and intra-communal relationships
	Foster economic activity	Economic value	DPI can improve financial inclusion and mobilise the potentialities of economic agents
	Guarantee essential capabilities	Capabilities and human rights	DPI can create the capabilities for individuals, businesses and agents of society to participate and thrive in all dimensions of their lives
	Guarantee better quality of life	Essential Needs and Human Rights	DPI can guarantee the essential needs for human life, enhancing the overall well-being and happiness of the population, including considerations such as healthcare, education, and cultural enrichment.

Source: Authors' elaboration

We explore different ways in which the value of infrastructure has been associated with attributes and functions, and reflect on how they can be applicable or are limiting for DPI. In practice, most organisations do not use a single frame, but combine them to justify the different social benefits that DPI can create. Still, the exercise of unbundling the frames and analysing them in isolation is helpful to make explicit the assumptions about value creation that are embedded in the current narratives about DPI's potential.

4.1.1 Public benefits of DPI associated with its attributes

Be interoperable through open standards

One of the ways in which traditional infrastructure generates **dynamic efficiency** is by fostering **competition through interoperability**. Interoperability ensures seamless interaction and collaboration among various entities within shared systems, facilitating competition in diverse sectors. The standardisation of electrical grid protocols is one example. Common technical norms across the diverse elements of the electrical grid — transformers, meters, control systems, and even socket ports — enabled a high level of interoperability. This uniformity in communication protocols allows different equipment and technologies from various manufacturers to integrate into the grid seamlessly. The adherence to standardised protocols has facilitated the entry of multiple players, creating a competitive environment where various entities can contribute innovative solutions and services.

In the digital space, one of the interpretations of the publicness of DPI argues that DPI may also increase competition if it is built following the attributes of interoperable standards[8]. Interoperability **helps prevent lock-in and legacy problems** that are commonly associated with IT systems (Bispal et al. 1999). In addition, the upfront investment expenditures of DPI are not of the same magnitude as large-scale physical infrastructure investments. In other words, when a digital infrastructure follows open standards and interoperability, 'shared means to means' becomes a more powerful 'universally shared means to many ends'. The Center for Digital Public Infrastructure has been an important player in advocating for interoperability as a fundamental attribute that defines the publicness of DPI. For them, interoperability is the first and perhaps most important feature distinguishing regular digitisation efforts from the DPI approach, because it creates individual choice and drives market competition (Center for Digital Public Infrastructure 2023).

From these attributes' perspective of publicness, Amazon Web Services (AWS), for example, is not considered a DPI because its architecture does not follow interoperable open standards. Like other major cloud providers, AWS strategically introduces proprietary services to create differentiation and foster vendor lock-in, making it difficult for customers to transition to alternative platforms. While this approach promotes rapid innovation and optimisation within its system, it raises concerns about the long-term implications of limited interoperability, and potential challenges for customers seeking flexibility and freedom from a single provider. Put simply, ASW does not offer 'universally shared means to many ends'.

> One example of how interoperable standards of DPIs shape competition is Brazil's instant payment digital infrastructure, Pix, operated by its Central Bank. Before Pix, each financial institution used its own transaction systems and set its own fees. Banks competed for transaction fees and the market was highly concentrated. After Pix, which enables instant payments at zero cost for citizens and runs in an interoperable Central Bank architecture, competition has shifted away from fees to focus on the quality and quantity of services that financial institutions offer.

Be built using reusable building blocks

One of the interpretations of the layered modular digital infrastructure outlined by Yoo et al. (2010) is that digital infrastructures are not only **modules, but can be divisible** and create

8 Interoperability can be generally defined as 'the ability to exchange information and mutually to use the information which has been exchanged' (Commission of the European Communities 1991).

even more powerful modular subcomponents. Analogue infrastructures do not have this feature, as they are technically indivisible[9]. A helpful analogy might be to think of reusable building blocks such as Lego bricks. Digital 'Lego bricks' are associated with a **powerful capacity for innovation and scalability** since the building blocks, like Lego bricks, can be used to build many other goods, services and infrastructures. McAfee and Brynjolfsson (2017) describe the **potential of combinatorial innovation** of reusable building blocks as 'coming up with something new and valuable not by starting from scratch, but instead by putting together in new ways things that were already there (perhaps with a few generally novel ingredients)' (McAfee and Brynjolfsson 2017).

The Digital Public Goods Alliance's GovStack Community of Practice (2022) has conceptualised reusable building blocks as part of 'DPI ecosystems'. According to them, digital public goods (DPGs)[10] and building blocks constitute a country's DPI. In their definition, building blocks are 'software code, platforms and applications that are interoperable, provide a basic digital service at scale, and can be reused for multiple use cases and contexts.' In this definition, which is shared by the Center for Global Development (2021), reusable building blocks have four features, which constitute a microservices architecture:

I. Autonomous: provide a standalone, reusable service or set of services; they may be composed of many modules/microservices.

II. Generic: are flexible across use cases and sectors.

III. Interoperable: must be able to combine, connect and interact with other building blocks.

IV. Iterative evolvability: can be improved even while being used as part of solutions.

One example of reusable building blocks can be found in India's Sunbird project. In 2017, funded by EkStep Foundation, Sunbird started building modular, free and open-source (FOSS) digital infrastructure based on the essential functions performed in school. Anuvaad, a module that provides translation capabilities for Indic languages[11], is one of Sunbird's initiatives. As a building block, Anuvaad can be used and plugged into any solution in education and other general administration sectors. For instance, Anuvaad is used in India's National Education Platform (Diksha) and SUVAS, a software launched in 2019 by India's Supreme Court to translate official documents. This shows that the architecture of the building blocks (or microservices) can help create solutions for different uses through its 'plug and play' features.

Be built using open-source licenses (or be unlicensed and in the public domain)

In economics, infrastructures are characterised by their potential for creating positive externalities (Otto and Voss 1995) typically associated with being 'impure' public goods. A 'pure' public good has two fundamental attributes: i) non-excludability and ii) non-rivalry. A good is considered ***non-excludable*** when it is costly or impossible for one user to exclude others

9 In IT terminology, this attribute is often called a microservices architecture.

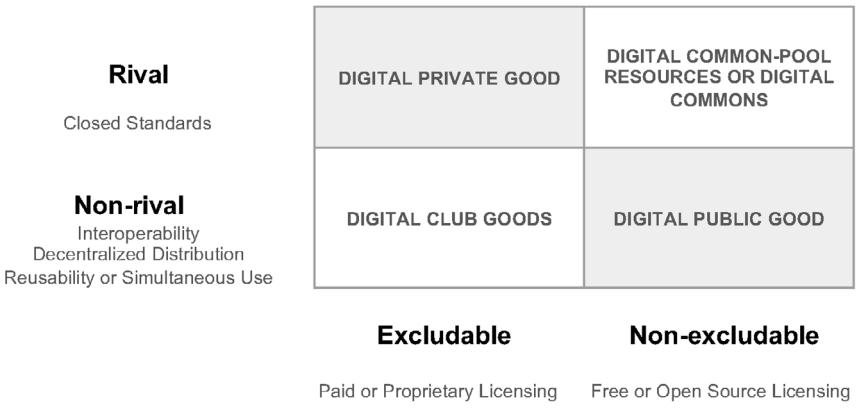
10 The Digital Public Goods Alliance considers digital public goods to be 'open-source software, open standards, open data, open AI systems, and open content collections that adhere to privacy and other applicable laws and best practices, do no harm, and help attain the Sustainable Development Goals (SDGs).' Available at: https://digitalpublicgoods.net/digital-public-goods/ (Accessed: 10 January 2024).

11 In India, there are 22 official languages and more than 300 unofficial languages.

from using it. One example is the Centers for Disease Control and Prevention (CDC) Covid Data Tracker, freely available to anyone worldwide who wants to visualise, compare or analyse the standardised Covid data (CDC 2023). A good is ***non-rivalrous*** when its consumption by one person does not reduce the amount available for others. Data, for example, is non-rivalrous because there are no scarcity constraints to its consumption. The differentiation between market-based private goods and non-profit public goods based on the attributes of excludability and rivalry originates from neoclassical microeconomic theory and welfare economics. It is based on the assumption that individuals pursuing their self-interest in competitive markets lead to the most efficient results (Mas-Colell et al., 1995; Samuelson 1947). However, in practice, very few are 'pure' public goods, as many are partially rivalrous or partially excludable (toll roads, for example). Thus, the typical examples of infrastructure fall under the 'impure' public good category.

The public good is well embedded in market failure theory, which accepts public intervention in the economy only if it is geared towards fixing situations in which markets fail (Mazzucato 2023). This approach suggests that governments intervene to fix markets by investing in areas characterised by positive or negative externalities. Public goods with positive externalities are characterised by underinvestment as their high spillovers create difficulties for appropriating private returns. It is more about corrections than objectives. The opposite happens when there is excessive investment in damaging areas, such as industries that cause pollution. Such negative externalities require public measures that prompt the private sector to internalise those costs, for example, a carbon tax to cut emissions or a tax on cigarette purchases. The limit of public good scholarship is that it treats some of the most systemic problems in global capitalism (e.g. climate change and inequality) as externalities and the results of failures of an otherwise perfect system rather than questioning the structures underlying the market system itself (Nelson 2022).

Figure 2. The four types of economic goods in the digital space



Source: Authors' elaboration based on Hess and Ostrom (2003)

In the digital domain, a good is an (impure) *public good* if it is universally or almost universally accessible and if there are no or minimal constraints to computing and processing power as the number of users increases. In technical terms (see Figure 2), this happens when the digital infrastructure is built with interoperable standards, is reusable and uses **open-source software** (or is unlicensed and in the public domain). However, this technology-based definition says little about the types of governance and collaboration necessary to ensure inclusive and sustainable DPI from an economic point of view. Indeed, from a global technology-based perspective, DPI-built open source can allow adoptability and adaptability of one country's DPI to other geographies (for example, see Estonia's X-Road). Within a country, implementing DPI layers as open source can allow for more scrutiny

and accountability, collaboration with other implementers and potentially more trust in the technology. However, open-sourcing DPI is no silver bullet, as there are also many other aspects needed if the goal is adoption by other countries. First and foremost is relevance, but code quality, documentation, governance and support also matter.

One example of open-licensed DPI is Estonia's X-Road, a free and open-source data exchange solution. As of November 2023, at least 22 countries had implemented some version of X-Road and benefited from the positive externalities of data exchange and not having to design their system (X-Road Global 2023). It has also spawned several proprietary clones – often from the same open code base – that offer a similar service, but with proprietary software and commercial licences, such as Cybernetica and Roksnet.

4.1.2 Public benefits of DPI associated with its functions

Foster community and social relationships

The notion that infrastructure creates social value is based on its potential to help shape communal, not individual, life. In this narrative, usually pronounced by anthropologists and social scientists, infrastructure's interconnectedness and relational aspects make it public. Infrastructure resources that generate **social value** include parks, public spaces and even the internet. Some discourses that highlight the social value of infrastructure define it as follows:

- The material and organisational foundations of collective existence
- The networks, systems and institutions that link people, places and things together
- Those physical spaces in which regular interactions are facilitated between and within the diverse sections of a community, and where meaningful relationships, new forms of trust and feelings of reciprocity are inculcated among local people
- The principal function is to foster inter- and intra-communal relationships (The Bennett Institute 2021).

In the DPI space, the most prominent voice in this discourse is Zuckerman (2020), who defines DPI as 'the infrastructures that let us engage in public and civic life in digital spaces.' Focusing mainly on public and social media, he argues that only some digital infrastructures are designed primarily for civic goals. He suggests that DPIs could be built with more purpose and intention toward the common good.

Foster economic activity

In this perspective, typically pronounced by economists, public infrastructure is justified by the **economic value** it creates. One example in the non-digital space is from Buhr (2003), who defines infrastructure as 'the sum of all relevant economic data such as rules, stocks and measures with the function of mobilising the economic potentialities of economic agents'.

In the DPI domain, this narrative is particularly strong in developing economies. Countries tend to highlight two potentials. The first is the notion that DPI supports a digital economy with potential for economic growth. India, one of the leaders in the DPI space and the host of the 2023 G20 meetings, has used this discourse to justify building its digital ID (Aadhaar), open payments system (UPI) and a consent-based data layer. The three together constitute the India

Stack.[12] The second is DPI's potential for fast-tracking economic development (Mukherjee and Maruwada 2021), usually focusing on the most vulnerable. For example, the World Bank's Identity for Development (ID4D) program is structured around the assumption that producing proof of identity is associated with various dimensions of development (World Bank 2022).

Guarantee better quality of life

In this perspective, the publicness of infrastructure is justified by the guarantee of **essential human needs** (Buhr 2003). For example, the need for medical care is met by the supply of hospitals, which are capital goods and a specific type of material infrastructure (Torrisi 2009). In the physical domain, Buhr (2003) provided a categorisation of material infrastructures that are needed for essential physical needs (i.e. warmth, health, water, light and protection against nature) and social needs (i.e. security, information, education, mobility and environmental protection). This framing intersects with a human rights perspective. Access to these infrastructures is not merely a matter of interest or convenience, but a question of upholding human dignity and ensuring equality of opportunity. For instance, the right to health, education and information are enshrined as fundamental human rights in various international charters and declarations.

In the digital domain, the right to an identity, prompted by the United Nations' Sustainable Development Goal (16.9) to 'provide legal identity for all, including birth registration' by 2030, has been one of the most evoked arguments for providing digital IDs as DPI. This perspective is also starting to develop for sectoral DPI in areas such as healthcare, education, mobility and security, and necessitates a discourse around DPI that extends beyond its technical aspects. It advocates for DPI as a pivotal element of just societies, where the digital divide, for example, is addressed not only as a technological challenge, but also as a matter of **human rights**.

Guarantee essential capabilities

The essential capabilities view of the value generated by infrastructure highlights its potential to provide the capabilities for societal agents to thrive in social, economic, political, civic, communal or familial roles. This view is influenced by Amartya Sen's capability approach (1985), which claims that well-being should be understood in terms of people's capabilities and functions. For Sen, capabilities are 'the doings and beings that people can achieve if they so choose' and functionings are capabilities that have been realised. This discourse falls into the functional category because a capability is achieved if a set of means (or infrastructure resources) can be converted into a functioning, for example the capacity to participate in the digital economy.[13]

In the digital space, this discourse has been one of the most popular to justify the publicness of digital infrastructures. The argument follows **Amartya Sen's understanding of human rights:** if a person does not have the **capabilities to participate in a digital society**, the person is excluded from opportunities and loses their freedom. This is the underlying assumption behind Eaves and Sandman's (2023) definition of DPI as 'society-wide, digital capabilities that are essential to participation in society and markets as a citizen, entrepreneur and consumer in a digital era.' Through the capabilities' lenses, there is consensus around three types of DPI – data sharing, digital identity and digital payment layers – although these categories are evolving.

12 More on the India Stack is available at: https://indiastack.org/ (Accessed: 12 November 2023).

13 One of the most famous understandings of the essential capabilities discourse applied to infrastructure stems from economists Larry Beeferman and Allan Wain (2016): '[Infrastructures are] facilities, structure, equipment or similar physical assets – and the enterprises that employ them – that are vitally important, if not absolutely essential, to people having the capabilities to thrive as individuals and participants in social, economic, political, civic or communal, household or familial, and other roles in ways critical to their own well-being and that of their society, and the material and other conditions which enable them to exercise those capabilities to the fullest.'

4.2 Are functional and attribute perspectives to public value enough for defining the 'P' of DPI?

In the subsection above, we unpacked the underlying values associated with different perspectives on the publicness of DPI, showing that DPI is not neutral. While, in practice, organisations rarely rely on a single perspective, looking at the different narratives in isolation makes explicit the assumptions about value creation embedded in how DPI potential is justified. But should one care which narrative is used? Moreover, are these categorisations satisfactory for defining the 'P' of DPI?

Clearly, building DPI with an attributes perspective to public value creation instantly creates societal benefits. For example, designing DPI to have open standards, being built with reusable components and open-source software, contributes to many dynamic efficiency gains (such as increased and improved competition, network effects, and the circulation and dissemination of knowledge in the economy).[14] These features also foster the system's scalability and access. **However, the attributes perspective is broadly agnostic on the direction of outcomes.** It assumes that innovation emerging from the infrastructures will create positive spillovers in different markets and formats, and those should not be restrained or pre-defined. While this is undoubtedly a positive consequence of the attributes outlined in this paper, its downside is to possibly waste DPI investment and implementation efforts in areas that are not policy-relevant or priority.

In contrast, functional perspectives, by definition, make explicit a direction for societal impact. For example, a needs-based discourse would justify building DPI for essential goods enabling human existence, which is a restrained scope for DPI's impact. **However, a solely functional perspective is also limiting.** Suppose DPI is built with a specific function in mind, but does not comply with attributes. In that case, it might waste an opportunity for societal impact and be less resilient to political shifts. For example, building digital identities that are not reusable, interoperable and open does not maximise the impact that takes place when the digital ID is designed for multiple use cases and at scale. Features are also complicated to change over time, whereas an ill-intended leader can reshuffle governance more easily. They are thus critical to the sustainability and endurance of public values.

If one is genuinely concerned about public value maximisation, understanding the 'P' of DPI through a combined functional and attribute perspective is desirable, because it expands the potential for creating public benefits. **However, only answering what public values are embedded in DPI is not enough.** At least two arguments can be made. The first is about **governance**. Although both attributes and functional perspectives alone create some form of value, as described above, none account for the processes surrounding value creation and maximisation, and the political economy implications. For example, nothing intrinsic about the attributes or functions of DPI creates inclusion, transparency and trust. These are achieved not only through features, but also through processes, i.e. governance. Second, both discourses are broadly silent on the **state's role**. In the policy discourse, it is expected to find economic perspectives which see the state's role as fixing market failures or being unable to deliver more quality than the private sector. This framing is not helpful. Achieving ambitious goals aligned with public values requires proactive governments who set the direction for the required collective action (Mazzucato and Ryan-Collins, 2022).

14 This architecture provides a minimum, standardised set of shareable components that allow for further decentralisation of the ecosystem's capacities and organisational structure. It thus creates the conditions for a dynamic system of innovation (Lundvall 1992), which builds horizontal and vertical linkages between actors and breaks organisational monoliths. These dynamic systems allow organisations to share data, knowledge and potentially work together on different societal challenges.

So how to maximise public value? In the next section, the discussion centres on how a 'common good' framework, when applied to governance, has the potential to enhance the public value creation of DPI.

5. Taking the 'P' seriously: governing DPI for the 'common good'

The different lenses on the publicness of DPI, which can be pronounced in isolation or recombined to justify DPI's potential, illustrate that DPI's **value creation potential** is significant. As argued, one possible implication for the DPI ecosystem is to consider the value creation of DPI from both technical attributes and a functional perspective. However, defining normative values is not enough for **public value maximisation**. As discussed in section 4.2, the different notions of publicness are limiting, because they are broadly silent on governance and the state's role. In this section, we argue that these two elements are essential for **public value maximisation** and we propose a **common good framework**, as developed in Mazzucato (2023), to strengthen the public value creation of DPI.

5.1 From public values to public value maximisation

Consider the Mastercard, Visa and American Express examples in section 4. One can argue that these companies create public value because they contribute to financial inclusion by providing payment solutions, allowing individuals to participate in the global economy. It can also be argued that the widespread use of Mastercard and Visa facilitates efficient and convenient transactions, reducing the reliance on cash and streamlining economic activities. This efficiency benefits individuals, businesses and governments, contributing to economic development. Yet, because merchants transfer their fees to retail prices, the indirect 'credit card tax' is estimated to reduce annual consumer and total welfare by $7 billion and $10 billion, respectively (Wang 2023). **Are payment systems offered by credit card operators maximising public value creation?**

First, it is not even clear that they are creating public value. Public value creation, an evolution from the notion of *public values* articulated by Bozeman, is not just about measuring how society benefits from the value created; it is also about how it is created in the first place. The value creation *process* (i.e. its direction, how it happens, who is involved and who guarantees it – more than who runs it) matters. Typically, the details of a collective value creation process are not debated. One of the reasons is that this discussion foregrounds a state versus market dichotomy; a reflection of a market failure policy narrative that has yet to move past the idea of which player has more capacity to deliver results efficiently. However, Bozeman's (2002) work on public values, which builds on Moore's (1995) seminal work on public value management (PVM) theory, calls for efficiency not to be the leading argument for policy delivery just 'by force of available analytical tools'. Bozeman argues that efficiency is one of many 'public values' (see definition in section 4) that the public could hold at any time.

If Bozeman's argument is accepted, the question becomes: how to go past the state versus market dichotomy? The key is to understand public value creation as a process **co-created** by the public and private sectors, not only created by one and fixed by the other (Mazzucato and Ryan-Collins 2022). In practice, this conception of public value creation means

that widely accepted societal goals can be achieved in **collaborative innovation processes** between different societal actors that co-create markets (Mazzucato 2016). To effectively generate such outcomes, the availability of expertise and competencies is essential in the planning, implementation, management, and coordination among various interest groups (Mazzucato and Kattel 2019).

In addition to public value creation, **public value maximisation** implies a more proactive and entrepreneurial attitude to dynamically create and shape new markets, i.e. 'transformation' (Mazzucato 2016). A market failure policy narrative fails to account for the innovation capacities required for structural and transformative change. It also does not say anything about the direction of change. However, societal transformation requires moving away from an agnostic view of digital public infrastructure towards a more purposeful and intentional one. Thus, a revived notion of the 'common good' that is not nested on fixing, but more on shaping and creating is useful (Mazzucato, 2023). **So what does the common good mean and how can it translate into market-shaping governance for DPI?**

5.2 The common good and the role of the state

The common good is a philosophical principle that extends beyond the mere attainment of common objectives, foregrounding the common processes and relationships needed to achieve them (Dupré 1993; Hussain 2018). Applied to economics, it moves beyond maximising individual preferences and creating Pareto-efficient outcomes as the ultimate goal of economic activity (Tirole 2017; Felber 2018). It shows that the 'how' of a journey towards a goal is just as crucial as the destination itself. A 'common good' framework can strengthen public value maximisation through an impactful governance model for DPI. In contrast with the conventional views on the public good and even the broadly defined public interest, the common good is not a correction, but a bold objective reached collectively (Mazzucato 2023).

The common good builds from the discussions around publicness outlined in section 4, because the first step for the common good is to know what to consider to create public value. Only then can it move to the stage of articulating collective objectives and governing the economy for the common good. The common good is not restricted to the values created by attributes or functions of DPI, but it moves towards the **collective good** regarding both **outcome and process**. In the common good framework, the process is almost as important as the final result and, therefore, governance issues are critical. After all, markets are outcomes of governance. Thus, rather than focusing on market failure or DPI neutrality, more proactive forms of governance that can generate desirable market outcomes are needed (Mazzucato 2016).

A renewed understanding of the state's role as a market shaper and entrepreneur is central to the notion of a common good. The proactive role of the state has been conceptualised in the entrepreneurial state (Mazzucato 2013), building on Polanyi's (1944) views of markets as co-created by the state[15]. This requires understanding the role of the public sector not only as market regulators, but also as a shaper and potentially even as an investor or co-investor of first resort, not last resort, capable of influencing the quality of market outcomes. Such a role requires not just bureaucratic skills, but vision and real technology-specific and sector-specific expertise. However, because the state's contribution has been understated, the state's full potential as an innovator and value creator has not been realised. Thinking of the state as 'levelling' the playing field – instead of tilting it – has reduced its confidence in its

15 Polanyi (1944) sees the market itself as constantly negotiated and shaped by how different actors creating value in the economy are governed. By characterising markets as embedded in social and political structures, he challenges the limiting state vs. market dichotomy. Markets are not idealised, but are seen as outcomes of governance structures shaped by the state (Evans 1995).

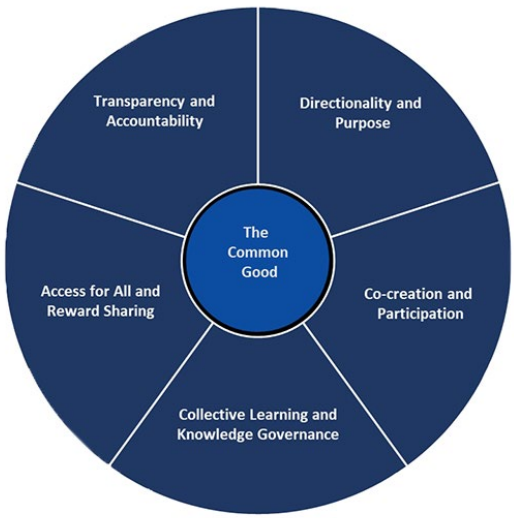
capabilities and has made it more vulnerable to being captured by vested interests.

Another argument for the state to take a more proactive role is the need to develop sovereignty, i.e. the retention of essential capabilities to deliver public value and promote the common good. When the state outsources some of its functions, it loses institutional memory and overall implementation capacity in the long run. Unless the state engages in building DPI, essential societal functions will be the exclusive (knowledge) property of private corporations, usually even foreign ones. This results in most states losing sovereignty and affects public institutions' ability to guarantee the common good pillars. This vision does not imply that governments should be running and operationalising all the DPI components, but that there needs to be a minimum mass of implementation capacity to ensure meaningful regulative approaches.

Finally, governments play a critical role in setting the direction of the process through which collective action and coordination occur (Mazzucato 2023). If public value is created collectively for reaching the common good and the process matters as much as the intention, creating public governance structures that help different actors move collectively toward the common good is paramount (Mazzucato 2023). This requires an understanding of how public institutions can guarantee the following five pillars:

- **Purpose and directionality:** Setting an ambitious direction towards which policies may be designed, public-private partnerships formed and citizens engaged;
- **Co-creation and participation:** Defining the rules and mechanisms for co-investment, collaboration and coordination involving a diverse group of societal actors;
- **Collective learning and knowledge-sharing:** Rethinking institutional practices that support collective learning and build long-term capabilities and capacities;
- **Access for all and reward-sharing:** Ensuring that public value is distributed equitably (inclusive growth); and
- **Transparency and accountability:** Winning and retaining citizen's trust in tracking progress through practices that show commitment to transparency and accountability.

Figure 3a: The Common Good Principles

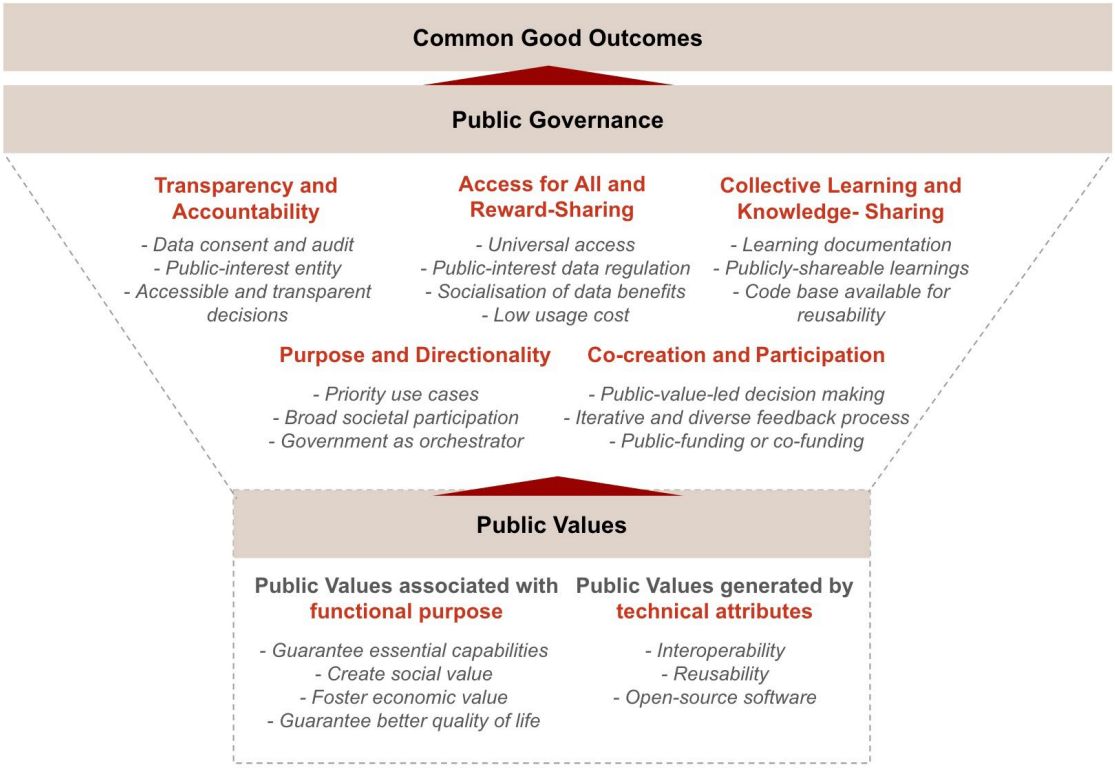


Source: Mazzucato (2023)

The pillars of the common good are not seen in isolation. Maximising public value toward the 'common good' requires three things (see Figure 3). First, well-defined public values, which

can be embedded in technical attributes and well-defined functional purposes (see section 4). Second, the five pillars of the common good can be translated into governance practices and processes. Finally, governance and values need to be aligned with clearly articulated and aspirational societal goals. Below, we further explore the five pillars outlined above and suggest directions for application in the DPI context.

Figure 3b: Governing DPI for the Common Good



Source: Author's elaboration based on Mazzucato (2023)

5.3 Purpose and directionality

In a 'common good' framework, setting directionality and orchestrating the process are two fundamental capabilities in a co-creative value process. The desire for a more explicit directionality in building shared digital infrastructure is a growing trend. Zuckerman (2020) reflects that, 'Our digital public infrastructures are only accidentally public infrastructures' and suggests that we should 'aspire toward a set of tools that are intentionally digital public infrastructures, spaces that operate with norms and affordances designed around a set of civic values.' Similarly, Cordella and Paletti (2019) argue that the adoption of a platform organisation (interpreted in this paper as a shared digital infrastructure) is not enough to deliver public value and that public administration requires a new mechanism of governance (i.e. orchestration) to guarantee the overall creation of public value.

DPI, like any form of infrastructure, is not neutral – it creates winners and losers, and shapes what can be built on top of it. Once one accepts that all infrastructure – regardless of intent – possesses 'directionality', then the nature of that direction should be made explicit and prioritised, as argued in section 4. One example is highways, which were initially created to serve a military purpose: to enable the quick redeployment of military equipment. This 'direction' shaped its other, better known 'long tail' uses (private logistics, commuting, shopping, taking holidays and others) that created the vast social benefits (and costs) and pulled billions of dollars of private capital into the process. This same direction made other use cases (highways as locations for walkways, sports areas or open-air markets) easier to imagine.

One case in which purpose and directionality are made explicit in DPI is India's identity system, Aadhaar (Eaves and Goldberg 2018). To the Indian government, the main reason for establishing residents' identity was to simplify the distribution of welfare benefits (including direct cash transfers, subsidised food, cooking gas and other benefits). The government feared that a substantial portion of those benefits was being wasted due to fraud and corruption. Building a system to identify an individual uniquely was paramount to prevent fraud and improve the targeting of social benefits. This directionality also made additional scaling easier. It turned out that a scaled identity solution was not only helpful for welfare benefit leakage, but streamlined 'know your customer' (KYC) compliance for all sorts of critical services, from banking to telecommunications.

In contrast to the Indian case, the digital identity system in Jamaica was not built with an explicit, primary purpose in mind (Eaves et al., forthcoming). Initially, the Jamaican government declared an interest in building an ID system, but did not link it to a primary policy purpose. This allowed others to imagine the ID's purpose, fostering the distrust of civil society actors, who were suspicious of the government's intentions. It was also a wasted opportunity, as the government did not focus on developing a programme or application that would benefit its citizens.

Questions for policymakers on purpose and directionality

- What normative public values support the DPI creation?
- Is the DPI built considering priority use cases (without losing sight of broader applicability)?
- Are civil society organisations and other societal representatives involved in defining purpose?
- Is the government responsible for orchestrating the DPI design and implementation process?

5.4 Co-creation and participation

The notion of the common good emphasises collaboration, coordination and co-investment between governments, private companies, civil society, international organisations and even different levels of government. Whereas the market-fixing perspective corrects for government failures, the notion of the common good, despite suggesting a more proactive role for the state, is opposed to a top-down approach to governing the economy. For example, society is still wrestling with the consequences of the collective legacy of failing to sufficiently 'co-create' traditional infrastructure. The process of creating highways is deeply distrusted in many places, as their creation has often occurred via expropriating land from the most vulnerable, and often to serve and benefit wealthier and more privileged communities. This is why co-creation and participation are parallel to purpose and directionality, not subsequent steps, in the governance process.

Applying this pillar to DPI might mean that in the early stages of DPI conceptualisation, the state creates the institutional mechanisms for collaboration and finds a role for different societal actors to contribute ex-ante, not ex-post. The effort that this coordination requires cannot be downplayed, but it will likely significantly impact the chances for long-term policy success. It is important to note that achieving co-creation and participation around proprietary technologies, particularly if it is a commercial company and not the government with the rights to the

technology, is more challenging than an open-source or digital public good option.

Brazil's Pix is one example of the benefits of making an additional effort to engender a co-creative process in DPI. Launched in November 2020 by Brazil's Central Bank (BCB), Pix is an instant payments scheme that enables users – citizens, companies and government entities – to send or receive payment transfers in a few seconds at any time, including non-business days. The team that developed Pix broke paradigms even within their own institution, because it was not common in the BCB to build anything collectively or experiment with user-centric design practices (Vasconcellos and Eaves, forthcoming). However, the Pix team understood that to create a new means of payment and lead a societal change, they would have to build it with society. Therefore, they created the Pix Forum, a collaborative governance practice to co-create the solution with representatives from many societal groups. Pix Forum had more than 130 members, including the most obvious (such as credit card operators, banks and fintechs), but also civil society organisations and small business associations. Although processing the feedback from more than a hundred participants made the process harder, the team considers this a central element of its success.

Questions for policymakers on co-creation and participation

- Are explicit public values driving key design and governance decisions?
- Is there a process for gathering and meaningfully integrating the perspectives of a diverse group of societal actors?
- Is the DPI being publicly funded or co-funded?

5.5 Collective learning and knowledge-sharing

A genuinely collective value creation process requires that actors involved in the implementation learn from each other's successes and failures, and evolve in their innovation process. In addition, an institutionalised learning process and accumulating institutional knowledge create long-term state capacities. Therefore, the orchestrators of the value creation process must find ways to encourage collective intelligence and knowledge-sharing.

Innovative institutional examples may be a vehicle for collective learning. One example is Bangladesh's Aspire to Innovate (a2i) programme, whose goal is to 'drive collaborative digital innovation for the public good.'[16] In practice, it serves as a think tank inside the government, focused on technology projects that are geared towards helping the country achieve the SDGs. The programme is an arrangement that allows the government to integrate inputs from, and collaborate with, civil society groups. More importantly, the model provides lessons to the DPG ecosystem in Bangladesh by demonstrating the capacities and talents needed to support the maintenance of digital public goods.

Another way to encourage collective learning with DPI is through incentivising open-source software and communities of code, a movement led by enthusiasts of digital public goods. For effective collective learning, engaging external contributors is key (Eaves et al. 2022). MOSIP, a solution focused on supporting countries to implement open-source identity systems,

16 See more about a2i here: https://a2i.gov.bd/ (Accessed: 14 December 2023).

offers an interesting open approach to contributors.[17] While some components are closely governed with limited room for external input to avoid adopters bypassing the safety and do-no-harm mechanisms built into the technology, others are more open to external contributions. Contributors can then introduce new features or fix bugs, covering a spectrum of tasks, from requirements and design to coding, testing and documentation. This comprehensive approach strengthens the system, establishing clear pathways for contribution while adhering to submission and reporting guidelines.

Questions for policymakers on collective learning and knowledge-sharing

- Are there processes for documenting learning?
- Are learnings publicly shared?
- Is the code base available for others to reuse?

5.6 Access for all and reward-sharing

The fourth pillar, access for all and reward sharing, is central to implementing the 'common good' in policymaking and directly affects the state's role. In this pillar, if an infrastructure is directed towards collective benefits, it must be universally accessible and its rewards must be shared with society. These two ideas are not always aligned with private interests. Therefore, the state has a role in guaranteeing them, even if the infrastructure is privately managed. Physical public infrastructure illustrates the point. For 10,000 years, physical public infrastructure has been a fundamental pillar of social and economic development. Infrastructure like roads, electricity, water and plumbing became *public* because they became essential to the functioning of society, so governments prioritised access and inclusion over market pricing and the possibility of rent extraction.

In the digital domain, guaranteeing universal access, particularly to DPI, unequivocally implies ensuring access through analogue means. Except for seven countries[18] where the share of the population that uses the internet is virtually 100%, waiting for universal internet access means imposing a burden on citizens; thus a non-digital solution is paramount. A few countries have explored creative solutions to analogue access. In Bangladesh, DPI was expanded to include an additional 'access layer', which turns DPI into 'phygital public infrastructure' (Chowdhury 2023). The access layer encompasses physical locations and call centres, improving DPI's accessibility for individuals with disabilities and those in underserved communities in remote rural areas. Bangladesh's over 9000 digital centres (also known as one-stop shops), widely spread at an average of 4km from a person's house, are run by young local entrepreneurs (a third of whom are women). These public-private partnerships guarantee that government services reach the grassroots level. Togo's Novissi, a COVID-19 cash transfer programme, is another example. Although the service was not available to every citizen, the Togolese government proactively reached out to the most vulnerable by leveraging the post office agencies and partnering with radio stations to communicate about the programme (Vasconcellos et al. 2020).

The efforts undertaken by the city of Barcelona can serve as an inspiration for reward-sharing mechanisms for DPI. Following the election of Mayor Ada Colau, Barcelona's government

17 See more about MOSIP here: https://mosip.io/ (Accessed: 12 November 2023).

18 Bahrain, Iceland, Kuwait, Norway, Qatar, Saudi Arabia and United Arab Emirates.

created a 'new data deal' agenda (Bria 2018), which aimed to promote greater use of corporate-controlled data for improving city services (City of Barcelona 2018: 15), as well as ensuring citizens could have more choice over how private platforms used their data. The city government reviewed its procurement processes and regulations to guarantee that the value extracted from data would not be privatised, but shared with the public. It introduced 'data sovereignty' clauses (Fernandez-Monge et al. 2023). In short, these clauses included the City's right and mandate to acquire data collected through or about the public services and some private sector data associated with the public interest, such as geolocation and data from ride-mobility operators. This example shows that besides regulation, procurement rules can be powerful policy instruments for the common good.

As DPI develops worldwide, it may also boost the power of AI algorithms. Since DPI potentialises the use and sharing of data, it is essential to take into account the inadvertent integration of existing biases into algorithms (for example Obermeyer et al. 2019; Yan 2021) and the unequally distributed benefits of big data that reinforce pre-existing structural inequalities on national and international levels (for example Hilbert 2016; Blumenstock 2018; O'Reilly et al. 2023; Strauss et al. 2023). It will be helpful to strengthen the dialogue with the scholarship on data democracy, and the right to access data and digital rights (for example Craglia and Shanley 2015; Morozov and Bria 2018; Kulkarni et al. 2020).

Questions for policymakers on access for all and reward-sharing

- Is there a proactive effort to make the DPI universally accessible?
- Are there governance clauses regulating data for the public interest?
- Are the benefits of data use being socialised?
- Are the costs for using the infrastructure low or none?

5.7 Transparency and accountability

To win and retain trust in the policy process, transparency and accountability are critical for public sector organisations leading and orchestrating a DPI implementation. Unlike in monolithic organisational structures, in which accountability is vertical and hierarchical, DPI's decentralised architecture poses challenges to accountability across government departments and levels of government sharing the same infrastructure.

If accountability has become more challenging on the one hand, on the other, DPI has the potential to improve transparency. The more systems are integrated, the more digital footprints can be leveraged for transparency. One well-known example is Estonia's e-health portal, which allows citizens to see who has accessed their data and when.[19] The city of Barcelona, as mentioned previously, also worked on giving citizens more transparency about how private companies used their data. One of the ways these objectives were achieved was through using an open-source data-sharing infrastructure (Decode), enabling citizens to control their data as a common good and to share them on terms that are fair, transparent and accountable (Decode, n.d.).

19 More on e-Estonia is available at: https://e-estonia.com/wp-content/uploads/eestonia_guide_a5_230206_rgb.pdf (Acessed at: 15 December 2023).

Transparency also potentially enhances access by making initiatives more well-known and creating a stronger value proposition for citizens. However, transparency by itself does not guarantee accountability and trust. For example, if interactions with citizens through making data available are not operationalised in a user-friendly way, then the effect on trust can be neutral or possibly negative.

Questions for policymakers on transparency and accountability

- Can citizens and companies consent or audit how and when their data is being used?
- Are key decisions (technical and management) about the infrastructure available in an accessible language and format?
- Is the DPI governed by a public-interest entity?

To take the public value creation of DPI seriously, the five principles outlined earlier should not be seen in isolation, but rather combined to achieve the notion of the common good.

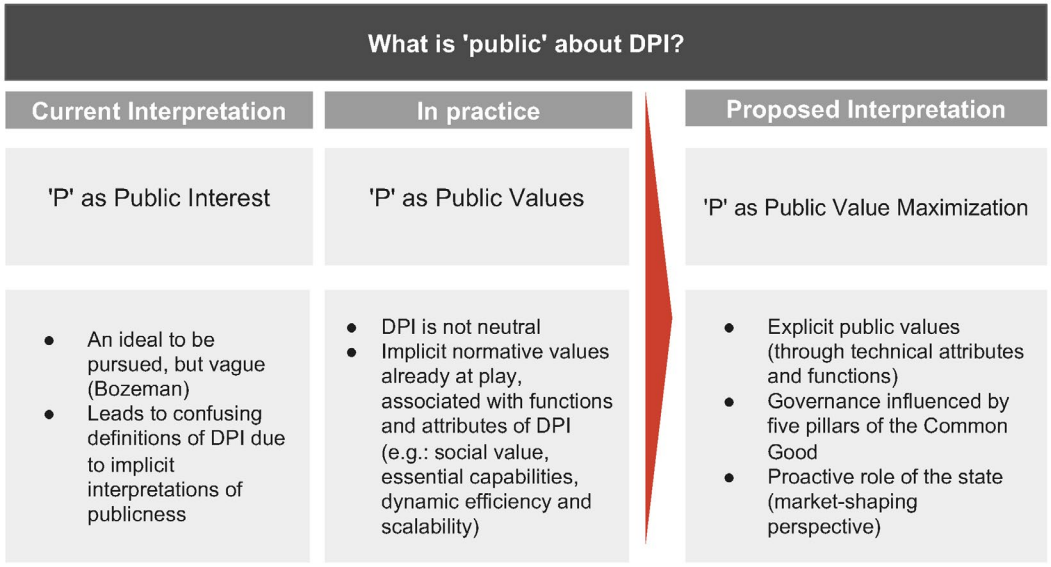
6. Discussion and conclusion

In the context of a growing interest in the DPI approach for achieving sustainable development goals and other societal impacts, major investments and decisions about the design and governance of DPI are taking place. This is a crucial moment for further reflection on the choices that can increase or harm the potential for public value creation.

In this paper, we outlined one central question for analysis: what does 'public' mean in digital public infrastructure? To answer this question, we argued that no infrastructure is neutral in directionality and demonstrated that DPI is no exception. We argued that the current narratives through which different groups understand the publicness of DPI, although vested under the broad concept of public interest, already embed a directionality through values generated by attributes or led by functions. We hope to have contributed to the literature and the policy world by making these values explicit (see Figure 3).

However, creating public value does not mean maximising public value. Although making values explicit is an important and necessary step for public value maximisation, it is insufficient. If one understands public value creation as a *process* co-created by the public and private sectors, not only created by one but fixed by the other (Mazzucato and Ryan-Collins 2022), then functions, attributes and even public provision are limiting. We suggest that the debate on DPI starts by making public values explicit, but that it goes beyond it. Public value maximisation must be a collective effort focusing on outcomes and processes towards the common good. In this process, the state has a renewed role in guaranteeing and orchestrating DPI. The 'common good' framework (Mazzucato 2023) and its five principles emerge as useful perspectives to strengthen DPI's value generation process with a focus on governance.

Figure 4. A summary of the paper's arguments



Source: Authors' elaboration

Therefore, one implication of our paper is that if we want the 'P' to be public value maximisation, there is no DPI without explicit public values, governance that follows the five pillars of the common good and a prominent role for the state. We leave a call for researchers in the public administration and digital government field to consider more robust investigations on the specific policy tools and management mechanisms required to apply a common good governance framework to DPI for creating even more public value. After all, as Star and Ruhleder (1996) remind us, infrastructure is only such when or while it facilitates value.

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