Unpacking Digital Public Infrastructures: Foundational Capabilities for Public-Interest Digital Value Creation.

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Abstract. Digital Public Infrastructures (DPIs) are an emerging concept for building foundational digital capabilities—such as digital identity, data sharing, and payments—designed and governed in the public interest to foster generative value creation. Although DPIs are increasingly promoted as instruments for enabling collaboration among governments, citizens, and organizations, the concept remains underdefined in both academic and policy discourse. This study addresses that gap by applying the Technology-Organization-Environment (TOE) framework and a grounded theory approach to analyze 143 academic and non-academic sources published between 2011 and 2024, including work from international organizations, think tanks, and philanthropic entities. We offer three primary contributions: First, we define DPIs as socio-technical systems with modular and layered architectures, governed through public-private collective action to support value creation and multi-actor interaction at scale. Second, we develop a conceptual framework structured around technological, organizational, and environmental dimensions. This framework identifies governance architecture and functional modularity, stakeholder orchestration, and public-private governance, as well as policy context and public rationale, as critical characteristics of emerging DPIs. Third, we position DPIs as an evolution of digital infrastructure and platform models, reoriented toward public interest objectives. We conclude with a call for interdisciplinary research to examine the design, implementation, and governance of DPIs across diverse regional contexts. Emphasizing their potential to deliver inclusive, interoperable, and scalable infrastructure capabilities, we argue that DPIs offer a promising foundation for addressing complex societal challenges.

Keywords. digital infrastructure, digital platforms, digital public infrastructure, digital public good, data ecosystems, public data spaces, government as a platform, platform regulation
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1. Introduction

The swift digital transformation of governments, economies, and societies has underscored digital public infrastructure (DPI) as essential for value creation and social advancement (Mergel et al., 2019; Yoo et al., 2024). In September 2024, the UN's Global Digital Compact committed to strengthening DPI to close digital divides and accelerate progress on the Sustainable Development Goals (United Nations, 2024), a pledge echoed under India's G20 Presidency (UN Development Programme, 2023a). The G20 agree that DPIs facilitate seamless ecosystem interactions among governments, citizens, and private organizations, addressing societal challenges while promoting inclusivity (UN Development Programme, 2023b). In doing so, they play a foundational role in shaping the ongoing digital transformation in line with a public interest paradigm, aiming to promote efficient value creation, improve citizen satisfaction, and promote decentralization (Henfridsson and Bygstad, 2024; Mergel et al., 2019).

Existing research on digital infrastructures highlights their dynamic, open, and heterogeneous nature, which has increasingly intertwined with digital platforms, enabling interactions that extend beyond organizational boundaries (Constantinides et al., 2018; Tilson et al., 2010). Digital infrastructures are evolving into platforms, while large digital platforms simultaneously function as infrastructures, increasing their foundational role in driving innovation and facilitating collaboration (Bygstad and Hanseth, 2018; Plantin et al., 2018). However, much of this research focuses on private digital platforms, which, in cases like hybrid conglomerate platforms such as Apple, Amazon, or Microsoft, have increasingly transitioned into quasi-public infrastructures due to their societal relevance (Degen and Gleiss, 2025; Gleiss et al., 2023). This shift has sparked debate around emerging regulatory issues leading to calls for digital sovereignty, inclusivity, and accountability of these private actors (Heimburg and Wiesche, 2023; von Scherenberg et al., 2024; Yoo et al., 2024). The emerging discourse on DPIs redefines these foundational digital infrastructures in the context of data sharing, digital identity, and payment by embedding public values such as transparency, interoperability, and accountability in their design and governance (Möller et al., 2024; UN Development Programme, 2023b).DPIs also leverage government-built digital assets and public data ecosystems, now open to third-party collaboration to deepen public-private impact and foundational relevance(Degen and Teubner, 2024; Degen et al., 2025).

Against this background, we conduct a literature review in Information Systems and Public Management, complemented by a grounded theory analysis, to develop a more systematic understanding of the emerging DPI concept. In doing so, we collected and analyzed through inductive coding more than 143 publications from scholars, think tanks, international organizations, and philanthropic entities addressing DPIs within the timeframe 2011 to 2024. We conceptualize DPIs as a socio-technical system with a modular and layered architecture, initiated and governed by public and private stakeholders through collective action. They serve as a shared foundation for value creation with large-scale societal impact, enabling interactions of multiple actors in the digital realm while advancing the public interest. Our research aims to contribute to the emerging field of DPIs by addressing the research gap in its conceptualization. Using the TOE framework as a theoretical lens, we explore the challenges DPIs face in generating impact (Tidd, 2001). Specifically, we examine the technological, organizational, and environmental dimensions that shape the "*DPI black-box*" and influence the design, governance and adoption. The central research question guiding our study is twofold:

How can digital public infrastructures (DPIs) be conceptualized and what technological, organizational, and environmental challenges shape their implementation and governance?

The remainder of the paper is organized as follows: Section 2 outlines the conceptual and theoretical background. Section 3 details research design, data collection and methodology. Section 4 presents the results and introduces the DPI framework. Section 5 offers a discussion and reflection on the findings. Finally, Section 6 concludes and provides an outlook for future research along the limitations of this study.

2. Conceptual and Theoretical Background

2.1. Digital Infrastructures and Platforms

IS research has conceptualized digital infrastructures as "*shared, unbounded, heterogeneous, open, and evolving socio-technical systems comprising an installed base of diverse information technology capabilities and their user, operations, and design communities*" (Hanseth and Lyytinen, 2004, p.4). These infrastructures are inherently

layered and complex, evolving through generative mechanisms such as adoption (through actor engagement), innovation (through new functionalities), and scaling (through stakeholder integration) (Hanseth and Monteiro, 1997; Henfridsson and Bygstad, 2013). Digital infrastructures can be broadly categorized into "heavyweight" systems, such as the internet or cloud computing, and "lightweight" systems, including smartphones and wearables (Bygstad, 2017). These infrastructures provide essential computing power and foundational services, thereby enabling digital innovation (Bygstad, 2017; Yoo et al., 2010). Their nature means they often become noticeable only during disruptions (Star and Ruhleder, 1996; Tilson et al., 2010).

In recent years, digital infrastructures have increasingly opened to third parties beyond organizational boundaries, undergoing a process that can be termed "*platformization*" (Bygstad and Hanseth, 2018). Simultaneously, private digital platforms built on these infrastructures have transformed governments, economies, and societies (Constantinides et al., 2018). Platforms employ modular architectures, with owners establishing value-creation mechanisms that shape interactions among ecosystem actors(Baldwin and Woodard, 2009; de Reuver et al., 2018; Hein et al., 2020). Prominent platforms, such as Apple, Microsoft, Alphabet, Amazon, and Meta, have undergone a process of "*infrastructurization*" (Plantin et al., 2018), evolving into de facto digital infrastructures that support conglomerate ecosystems through centralized governance structures (Degen and Gleiss, 2025). These entities now offer foundational services, including cloud computing, interaction channels (e.g., smartphone and messaging platforms), and matchmaking capabilities (e.g., app stores and marketplaces), thus shaping societal norms, values, and value-creation mechanisms (Gleiss et al., 2023). Despite their value proposition, these platforms face increasing criticism due to growing dependence on their services and governance challenges (Heimburg and Wiesche, 2023; Henfridsson and Bygstad, 2024).

Public discourse highlights a demand for greater "*digital sovereignty*" among citizens, organizations, and policy makers, focusing on resource control, fairness in value creation and distribution, and addressing power asymmetries (Pohle and Thiel, 2020; von Scherenberg et al., 2024). Moreover, it underscores the growing desire for increased public oversight and government involvement in shaping digital infrastructure platforms to better align with public interests (Degen and Gleiss, 2025; Gleiss et al., 2023). Repeatedly, the importance of developing scalable public-sector-led alternatives to address the shortcomings of current digital realities are highlighted (Zuckerman, 2020). These efforts represent a form of public innovation, often initiated and guided by governments in collaboration with private and civic actors (Klievink et al., 2016). The goal is to tackle complex societal challenges, such as digital inclusion and equitable access, while providing foundational infrastructural capabilities that enable value creation and drive societal progress (Zuckerman, 2020).

2.2. Public Innovation and Public Interest

Public sector-driven innovation has become a focus of academic and policy debates (Mazzucato, 2011; Panagiotopoulos et al., 2019). This interest is particularly notable in the context of public-private cooperation and partnerships, which are recognized as key drivers of innovation aimed at creating public value (Shiva et al., 2024). Building on foundational frameworks such as Moore's Public Value Theory (Moore, 1997), the concept of public value encompasses three main dimensions: accountability, service quality, and citizen engagement (Hartley et al., 2017). While these principles are widely endorsed, their application within highly collaborative and regulated environments, such as platforms and digital infrastructures, remains limited (Gleiß et al., 2023; Hermes et al., 2022). Despite challenges, DPI policy discourse strongly emphasizes three core promises of public innovation: solving complex societal challenges, enhancing service delivery through digital transformation, and increasing transparency and inclusivity Mergel et al., 2019; Panagiotopoulos et al., 2019. Public innovation is an undirected form of innovation that seeks to address systemic issues, such as climate change and digital exclusion, through collaborative efforts and technological advancements (Kankanhalli et al., 2017).

Public innovation is built upon three core components: technology, organizational processes, and citizen cocreation (Hartley et al., 2017; Moore, 1997). Together, these elements form the foundation for generating public value across economic, social, and political measures. Economic value includes cost savings, efficiency gains, and economic growth driven by public-private collaboration. Social value emphasizes enhanced equity, inclusivity, and access to essential services. Political value strengthens trust, transparency, and democratic participation. As such public technology innovation has to face harsh public evaluation. A critical aspect for selling public innovation investments to stakeholders is the feedback loop between innovation and value creation (Scott et al., 2016). Innovations drive public value, which, in turn, fosters support for further innovation. However, there are relatively few successful examples of public innovation that have not been at least partially privately sponsored. A trade-off becomes visible: while private actors are often necessary for achieving

economies of scale and delivering high-quality services, they require adequate returns on investment, creating potential tensions in balancing public and private interests.

Public innovation policy faces additional challenges, including balancing citizen demands to ensure that innovations meet the needs of diverse populations while maintaining political neutrality (Edler et al., 2023). It must also navigate preexisting legal complexities, addressing national and international regulatory frameworks, including data protection, trade agreements, and intellectual property regimes. Furthermore, creating incentives for public-private partnerships is essential to encourage private sector participation without compromising public accountability and equity. To overcome these challenges, public innovation must adopt a collaborative and multi-stakeholder approach (Hodge and Greve, 2007). Governments must create enabling environments that balance the at times competing demands of citizens, private partners, and regulatory frameworks. By fostering public-private partnerships and leveraging co-creation processes, public innovation can fulfill its potential to deliver meaningful and sustainable public value (Zuiderwijk and Janssen, 2014). In this a cornerstone are shared visions and transparency often only delivered by neutral third parties.

2.3. Digital Public Infrastructure and Digital Public Goods

DPI is a highly recent phenomenon emerging in policy and public discourse only over the last five years (Hadavand et al., 2021; Zuckerman, 2020). Its development is closely linked to the concept of digital public goods, a relationship that has been explored in the historical emergence of these systems. However, the academic community often experiences a lag in addressing newly emerging topics (Rosa and Scheuermann, 2008). Consequently, literature on DPI remains sparse and both theoretical frameworks and empirical studies are highly diverse and unstructured. In general, DPI refers to foundational digital systems that enable governments, businesses, and individuals to interact within a digital ecosystem (UN Development Programme, 2023b). Examples include digital identity systems, interoperable payment platforms, and open data initiatives. These systems are designed to facilitate access to services, enhance economic participation, and improve governance. Digital public goods (DPGs) are characterized as digital assets and resources such as data that are universally accessible and serve the public good (UN Development Programme, 2023a). These include open-source software, open data, and algorithms that promote equitable access to digital services (Kankanhalli et al., 2017). The United Nations (UN) defines DPGs as systems that adhere to open standards and principles, ensuring inclusivity and transparency (UN Development Programme, 2023a). Throughout a pre-clustering of available sources, a degree of interchangeable use of the two terms in discourse has been identified, not represented in empiric research. Because of this, we approach the relationship between DPI and DPGs as symbiotic in accessible publications. DPI is portrayed as relying on DPGs to ensure scalability, interoperability, and openness. For instance, a digital identity system may leverage open-source technologies (DPGs) to ensure cost-effectiveness and adaptability (Degen and Teubner, 2024).

Tab. 1 – Literature Representation of Digital Public Infrastructure

Research Stream	Brief Summary	Example Case	Example References
data exchange	Data exchange layers (or platforms) enable the transfer of information between stakeholders, e.g. companies, citizens, government.	India Stack x-Road Euro Stack	Aca-IS-22 Aca-S-40
identity	Digital identity systems provide individuals and organizations with verifiable means of identification without the need for further third-parties.	Aadhaar Diia PhylSis	Aca-S-31 Aca-S-22
payment	Payment systems facilitate digital transactions between citizens, businesses, and governments.	Pix UPI m-Pesa	Aca-S-18 Aca-S-42
public goods	Digital public goods encompass open-source software, data sets, algorithms, and platforms that are universally accessible and meant to benefit society as a whole.	eSanjeevani D-CENT	Aca-S-8 Aca-S-36

To achieve an initial overview of how the academic community has approached the topic, this study conducted a systematic literature review oriented at vom Brocke et al., 2009. Using the search operators "*digital public infrastructure*" OR "*digital public good*", we queried all fields in Scopus, AISeL, and AoM, resulting in a total of 82 publications (45 from Scopus, 35 from AISeL, and 2 from AoM). The findings from this review provide a

foundational understanding of how DPIs and DPGs have been academically treated and clustered, see Table 1. Information is accessible under: https://tinyurl.com/bdf8wet6. Although policy interest is rising, academic literature still lacks theoretically grounded definitions, empirical studies, and theory-driven research on DPIs. Insights stem mainly from lighthouse projects in India, Brazil, Estonia, and Singapore (UN Development Programme, 2023b), offering practical lessons but limited theory and often conflating DPI with DPG. While digital infrastructures and public–private partnerships have been studied (Ceccagnoli et al., 2012), no research has explicitly conceptualized DPI as a distinct phenomenon.

2.4. Theoretical Lens: Technology Organization Environment Theory

The Technology-Organization-Environment (TOE) theory provides a theoretical framework to understand how organizations, especially under high degrees of uncertainty (Tidd, 2001), adopt and implement new technologies (Awa et al., 2017; Baker, 2012). The TOE framework examines the interplay of three key contexts — *technology*, *organization*, and *environment* — and can be applied to explicate decision-making processes, particularly in the context of digital (public) infrastructure and data exchange (de Reuver et al., 2024). Originally introduced by Tornatzky and Fleischer in 1990 Baker, 2012, the TOE framework has gained widespread application in analyzing technology adoption and innovation Awa et al., 2017. TOE is foremost used to analyze the interplay between technological advancements, organizational dynamics, and environmental factors (Tsou and Hsu, 2015). This is particularly relevant in highly cooperative and regulated contexts (Yang et al., 2021), making it an appropriate theoretical lens to explore the complexities of public-private partnership dynamics in DPIs (Naithani and Agrahari, 2023). DPI serves as a prominent example of a highly complex system involving multi-actor stakeholders. These stakeholders include traditional public-private partnerships and extend to public-private-civic collaborations (Amard et al., 2024). For instance, the role of nongovernmental contributors, such as open source software (OSS) communities, is increasingly visible in the debate (Malgonde et al., 2023), alongside ongoing coordination challenges between BigTech entities and governmental institutions.

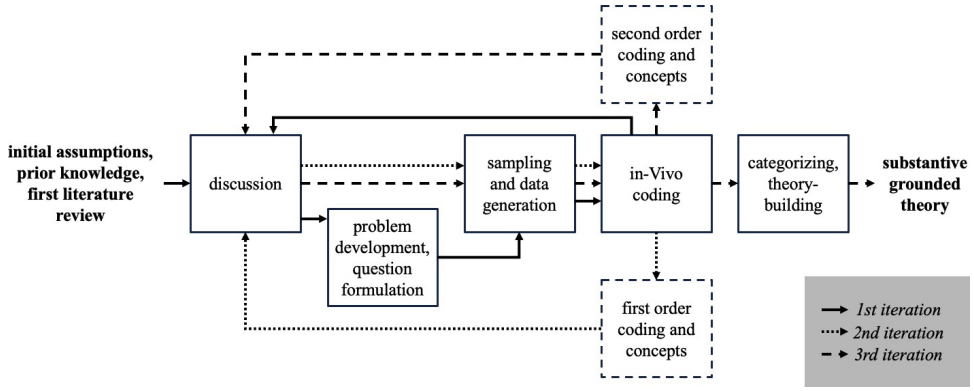
Within the TOE framework, DPI can be analyzed through three distinct lenses (Awa et al., 2017; Baker, 2012):

1. *Technological Foundations*: The technological characteristics of DPI, such as interoperability, scalability, openness, and cost-effectiveness, significantly influence its adoption and implementation. Examples include general digital platform foundations, digital identity systems, and payment gateways.
2. *Organizational Implementation and Management*: Governments, BigTech companies, non-profits, interest groups, and citizens all act as organizational actors with their own agendas, with distinct roles and interests.
3. *Environmental Influence in Cooperation, Legislation, and Regulation*: The broader environment, which includes collaboration, regulation, and competition, exerts a significant influence on DPI. Regulatory factors such as standards, modularity, law, and transnational regulation play a role in the formation of DPIs.

3. Data and Methods

3.1. Grounded Theory

Fig. 1 – Grounded Theory Research Process



DPI has gained significant attention, especially since India's G20 presidency (G20 India, 2023). Despite increased interest, definitions and theoretical work remain limited. To enable deeper analysis (Gregor, 2006), we used a grounded theory research design (Grover and Lyytinen, 2015; Wiesche et al., 2017), suitable for developing insights where theoretical foundations are weak (Corbin and Strauss, 1990). DPI's governance, mission, and scope implications make it ideal for grounded theory analysis (Birks et al., 2013; Urquhart et al., 2010). To reduce bias and reflect structural discourse, we examined academic work from management, law, and information systems, along with think tank reports and international organization publications. Our method involved iterative coding and constant comparison to identify key themes. By analyzing diverse materials, we aim to clarify DPI's conceptual and practical implications. This helps explain its multi-actor character and supports a structured understanding of DPI's role in governance and society. Figure 1 illustrates our process: team discussions, sampling, and data generation through in-Vivo coding repeated over three cycles.

3.2. Data Collection

Using the terms "digital public infrastructure" OR "digital public good", we retrieved 82 academic publications (2011–2024). Additionally, 61 non-academic sources—briefs, papers, blogs, reports, and practice research—were identified, with the earliest from 2020 (see Table 2). Non-academic searches focused on "digital public infrastructure" across the top 15 think tanks from the 2020 Global Go-To Think Tank Index (McGann, 2020) and top 10 from the 2024 Academic Influence rankings. Given DPI's emerging and policy-focused nature, including leading think tanks ensured timely, practice-driven insights that often precede academic theorization. A forward and backward citation analysis added relevant sources. All materials were open-access, English, and treated without quality differentiation. Data analysis involved in-Vivo coding to extract first-order concepts, which were iteratively grouped into broader categories. Second-order coding refined these categories into a grounded theory, supported by repeated review and abstraction cycles to ensure empirical depth and explanatory value. The TOE framework was applied following Gregory et al., 2018. Three researchers systematically reviewed all sources and conducted in-Vivo coding, see Figure 1.

Tab. 2 – Sources Used for Theory Development

Type	Outlets	n
academic article	SCOPUS, AoM, AISeL	82
blog	New America Foundation, Gates Foundation, Atlantic Council, Carnegie Endowment on International Peace, AI Now Institute, World Economic Forum, Council on Foreign Relations (CFR),	
brief	Atlantic Council, Open Knowledge Foundation, Konrad Adenauer Foundation, Fundação Getúlio Vargas (FGV)	7
paper	Brookings Institution, Carnegie Endowment on International Peace, Open Future, Chatham House (Royal Institute of International Affairs), Brookings Institution	7
report	Konrad Adenauer Foundation, Milken Institute, Center for Strategic and International Studies (CSIS), Project Liberty	6
commentary	Carnegie Endowment on International Peace, Chatham House (Royal Institute of International Affairs), Institut Montaigne	3
other	European Partnership for Democracy, Gates Foundation, Center for International Governance Innovation	6
Total		**143**

Data analysis involved in-Vivo coding to derive first-order concepts directly from the data, which were then iteratively categorized and abstracted into broader patterns and relationships. Through second-order coding, the team refined these relationships to develop a substantive grounded theory. The iterative nature of the process, highlighted by repeated cycles of data re-engagement, coding refinement, and theory abstraction, ensure that the resulting theory is both explanatory and empirically rooted.

4. Results

Employing the TOE framework (Baker, 2012), this research structures inductive findings around the technical, organizational and environmental context, proposing a comprehensive DPI framework. Additionally, to advance the conceptualization of DPIs, our study examines the challenges facing them in generating impact.

4.1. Technological Context: Governance Architecture and Functional Modularity

Tab. 3 – Example Sources DPI Technology Context

Context	Dimension	Practice Reference	Academic Reference
Technology	Governance Architecture	Pra-B-15, Pra-BA-4	Aca-S-1, Aca-S-5
	Functional Modularity	Pra-A-2, Pra-B-12	Aca-S-14, Aca-S-42

DPIs technological context can be understood through two key dimensions: the design of the governance architecture and the functional modularity of the DPI (Henfridsson and Bygstad, 2013). The design of the governance architecture describes the chosen technological innovation approach and the configuration of the infrastructure, which determines how centralized or distributed the DPI components and interfaces are. Functional Modularity refers to the feature set of the DPI system, which can be categorized into two key components: core infrastructure and enabling applications. Table 3 provides an overview of the technological context of DPIs, distinguishing the key aspects of governance architecture and functional modularity.

The technological innovation approach focuses on the trade-off between building upon legacy infrastructures and platforms, which often have established user bases, or developing entirely new infrastructure systems from scratch (Ozalp et al., 2018). Leveraging legacy systems enables the incremental enhancement of existing infrastructures by building upon established operational knowledge and the current user base. This approach facilitates the integration of new innovations, seamlessly embedding them into the core of the digital infrastructure to modernize it, a process that can be defined as DPI evolution. Conversely, developing an entirely new approach may replace existing offerings and components, potentially generating additional value, increasing efficiency, and reducing complexity through replacements. However, this approach necessitates building and operating the infrastructure from the ground up, a process referred to as DPI invention. For instance, the EUDI Wallet exemplifies a DPI that builds upon existing national EU electronic identification (eID) schemes (Degen and Teubner, 2024). It enhances functionality by introducing a new interface that broadens access for citizens and integrates multiple public and private identity data providers. This approach creates a robust identity data ecosystem through collaboration between public and private organizations, extending the scope and reach of existing digital identity infrastructures. In contrast, India's Aadhaar system represents a DPI developed entirely from scratch. It was designed to address the unique challenges of providing foundational digital identity verification to a diverse and large population (Desai and Manoharan, 2024).

The infrastructure configuration of DPIs impacts its technical architecture and governance. Centralized DPIs consolidate control under a single authority, enabling streamlined decision-making, standardization, and technical and organizational enforcement. This model is ideal for scenarios requiring regulatory oversight or uniformity. However, it introduces risks such as single points of failure, limited adaptability to diverse contexts, and heightened concerns around data privacy, surveillance, and abuse. Decentralized DPIs distribute control across multiple systems and organizations, promoting resilience, inclusivity, and local autonomy(Henfridsson and Bygstad, 2024). This approach distributes control through modularity, reducing risks such as single points of failure and limited adaptability through more flexibility. However, it requires robust frameworks for interoperability, resource allocation, and conflict resolution, which add to system complexity and can increase operational costs. DLT or Blockchain-based digital infrastructures, like Bitcoin, highlight the struggle to develop and govern decentralized infrastructures (De Filippi and Loveluck, 2016). Therefore, the choice between centralized and decentralized configurations is context-dependent, with hybrid models frequently combining both approaches to address diverse needs to achieve scalability, reliability, and inclusivity.

The functional modularity of DPIs can be differentiated into core infrastructure components and enabling application components, emphasizing the modular and layered characteristics of DPIs. This structure facilitates the recombination of capabilities and the seamless integration of functional layers, collectively forming the DPI foundations that enable generative interactions.DPI core infrastructure components include data storage systems designed to store and reuse data resources from diverse sources, enabling seamless data exchange across interconnected systems and organizations. These components extend beyond traditional sectoral boundaries, encompassing domains such as healthcare, financial services, and education. The European Gaia-X initiative in the cloud segment and the Estonian X-Road data exchange infrastructure exemplify these characteristics (Lips et al., 2023). As the foundational layer of DPIs, data exchange infrastructures deliver essential capabilities for large-scale data processing, connectivity, and interoperability (Pra-A-1). Cloud computing is a pivotal element of this foundational layer, providing the computational resources required to facilitate scalable and efficient

data exchange via data exchange standards and infrastructures. This foundation supports the deployment of enabling applications, which build on the core infrastructure to extend its functionality and tailor the DPI to specific usage contexts.

Enabling applications to provide advanced functionalities by bridging foundational infrastructure capabilities with the specific needs of diverse actors. These applications include components such as digital identity components (e.g., Singpass in Singapore), digital payment systems (e.g., Pix in Brazil), and increasingly, AI infrastructure capabilities (e.g. AI Commons) that align with the evolving technological advancements prevalent in the private sector (Pra-A-1). Enabling applications to operate across both heavyweight and lightweight infrastructures, leveraging their computational capabilities to deliver dynamic value tailored to user interactions (Bygstad, 2017). From an infrastructure configuration perspective, enabling applications are typically more distributed and decentralized compared to core infrastructure components. While core infrastructures are optimized for scalability, efficiency, and uniformity, enabling applications to prioritize flexibility and adaptability, making them more suited to address diverse and context-specific requirements. This more decentralized nature of enabling applications reflects their role in fostering generative innovation and enhancing the utility of DPIs within a variety of operational contexts.

4.2. Organizational Context: Public-Private Partnerships and Stakeholder Orchestration

Tab. 4 – Example Sources DPI Organizational Context

Context	Dimension	Practice Reference	Academic Reference
Organization	Public-Private Partnership	Pra-B-22, Pra-BA-4	Aca-IS-22, Aca-S-40
	Stakeholder Orchestration	Pra-B-11, Pra-B-4	Aca-S-14, Aca-IS-3

The organizational context of DPIs plays an important role in their initiation, governance, and operational effectiveness. Two key dimensions within this context are the structure of public-private partnerships and the orchestration of diverse stakeholders. Table 4 provides an overview of the organizational context in the two dimensions of public-private partnership and stakeholder orchestration.Public-Private Partnerships (PPPs) are fundamental to the organizational contexts of DPIs, necessitating strong collaboration among governments, private sector organizations, and civic actors (Stiglitz and Wallsten, 1999). The successful initiation, scaling, and development of a DPI requires not only technical capabilities and organizational resources but also the widespread adoption of DPI offerings by various stakeholders. Engaging the actors who will utilize the DPI is essential for fostering adoption, as it enhances the generation of tangible impact and demonstrates the societal relevance of the DPI to all stakeholders involved. For analytical clarity, two primary PPP models can be identified, though in practice, various hybrid combinations often exist and evolve over time to meet the demands of different contexts and life-cycle phases of a DPI.

In the first model, publicly owned – privately utilized, the DPI is owned by public entities but utilized by private organizations to leverage essential services that address existing organizational needs and build a foundation for value creation. Examples include government-owned digital identity infrastructures or health data-sharing platforms. This approach aims to ensure public oversight and is typically government-initiated, with digital infrastructures opened to private and other actors for broader collaboration and societal benefit. In the second model, privately owned – publicly regulated, the DPI is developed and owned by private entities but operates under public regulation to ensure alignment with societal and governmental objectives. Examples include privately developed digital payment systems (VISA, Mastercard) mandated to comply with public interest regulations. This scenario balances private investment and operational efficiency with public accountability, and typically, these privately owned DPIs emerge and are later regulated to ensure that public interests are strengthened.

Effective orchestration of stakeholders is essential for ensuring that DPI initiatives are inclusive, transparent, and aligned with shared goals to achieve collective action (Addo, 2022). Stakeholder orchestration can be conceptualized through two primary approaches: In the first scenario, the government leads the development and governance of DPIs, setting strategic objectives, regulatory frameworks, and operational guidelines. This approach is particularly effective in scenarios requiring strong public oversight, such as the case of government-provided digital IDs. However, it may face challenges in fostering innovation and adaptability due to constraints to control and avoid risks. In the second scenario, private sector stakeholders initiate and drive the development of DPIs, often in response to market demands or technological advancements. Governments

typically engage in a regulatory capacity, ensuring that the DPI aligns with public interest goals. Bottom-up models are highly adaptable and innovation-driven, exemplified by the emergence of private digital platforms such as Apple or Amazon that provide essential services for digital interactions. However, they require robust regulatory mechanisms to address risks such as monopolization or exclusion (Degen and Gleiss, 2025).

4.3. Environmental Context: Policy Environment and Public Rationales

Tab. 5 – Example Sources DPI Environmental Context

Context	Dimension	Practice Reference	Academic Reference
Environment	Policy Context	Pra-A-3, Pra-B-10	Aca-S-22, Aca-IS-3
	Public Rationale	Pra-O-1, Pra-O-3	Aca-S-6, Aca-S-10

Two key dimensions influence DPI beyond their technical and organizational context. First, DPI is promoted and shaped by emerging national and international initiatives and policies. Beyond this, public and policy discourse, especially about characteristics and objectives, influence perception and expectations towards DPI. Table 5 provides an overview of these two key environmental dimensions.

Recent national and international DPI initiatives have emerged, often focusing on their role in digital development. Prominently, India's G20 presidency in 2023 elevated DPI to the global stage by advocating for the concept, and citing domestic examples like Aadhaar and the UPI as models (Desai and Manoharan, 2024). International organizations like World Bank and the UN also recently embrace DPI to address challenges in different domains. Furthermore, the Global Digital Compact - adopted by the UN General Assembly in 2024 - emphasizes the need for collaboration to establish standards and systems for DPI (UN Development Programme, 2023b). These efforts demonstrate how DPI emerges as a recognized concept on national and international policy stages, understood as a tool aligning with different national and international objectives. Policy objectives range from equitable access to digital offerings, empowerment of citizens and organizations to participate in the digital economy and society, to ensuring privacy and security for various stakeholders in the interaction with core digital services. For example, digital identity components within a DPI stack can facilitate secure processes like e-voting, enabling widespread digital participation while maintaining trust and security (Egodawele et al., 2024). In addition, open data and data exchange capabilities (e.g. European Data Space Initiative) within DPIs ensure that public data is accessible and usable by multiple actors. Additionally, DPI is leveraged by early-adopter countries to showcase their national digital competence and success. Nations such as Estonia (e.g. X-Road), India (e.g. IndiaStack), and Ukraine (e.g. Diaa app), are frequently cited as examples for DPI benefits that leverage their achievements not only to strengthen their global position but also as an integral part of their national identity (Aurazo and Gasmi, 2024). For instance, Estonia proudly identifies itself as a "digital state," highlighting its pioneering role in the digital transformation arena (Lips et al., 2023). DPI solutions and components developed by national private sector players are actively promoted for export, showcasing a country's digital capabilities and fostering business opportunities abroad.

Objectives and rationales in policy and public discourse circle around themes of digital transformation, while also addressing concerns such as digital inclusion, privacy, security, and digital sovereignty (Zuckerman, 2020). DPIs are expected to provide a foundational framework that enables innovation, transformation, and value-creation across sectors. From a governmental perspective, DPIs contribute to modernizing public administrations not only internally but also in critical public service domains such as healthcare, education, and agriculture (Sandhu et al., 2023). By doing so, they can redefine and enhance digital interactions with citizens and organizations, creating more accessible, efficient, and user-friendly transactions. For instance, the Indian Unified Payment Interface (UPI) reshapes digital payments by creating a real-time, interoperable, and cost-effective infrastructure (Desai and Manoharan, 2024). Moreover, DPIs provide digital infrastructures to tackle issues that the private sector either cannot address (e.g., a foundational digital identity) or does not sufficiently prioritize (e.g., financial inclusion). This underscores the importance of offering public alternatives to enhance choice and sovereignty, reduce dependency on private-sector solutions, or motivate private actors to align more closely with public interests, such as fostering transparency and accountability.

Moreover, DPIs play an important role in empowering actors and strengthening digital sovereignty by ensuring equitable access, safeguarding rights, and promoting openness and alternatives. First, DPIs can enable access to essential services and foster civic participation by removing barriers to engagement through their legal and governance frameworks that support foundational offerings (Pra-B-15). By offering foundational

capabilities such as digital identity and secure data exchange, DPIs can enable access for all individuals, regardless of socioeconomic status, to vital services such as healthcare, education, and financial systems (e.g. Huduma Namba digital identity infrastructure in Kenya). Second, DPIs can contribute to the protection of digital rights and security. By embedding principles such as data privacy, transparency, and accountability into their design, DPIs can provide a secure ecosystem for digital interactions of multiple actors. Third, DPIs - depending on their design - offer open, publicly governed alternatives to privately initiated digital infrastructures and platforms. These alternatives reduce dependency on private platform infrastructure offerings, enabling nations to retain control and power over critical digital infrastructure capabilities (Pohle and Thiel, 2020). Finally, it may be argued that by promoting openness and interoperability, DPIs create an ecosystem that encourages competition and innovation. For example, India's Aadhaar system, integrated with other DPI layers like UPI, exemplifies how public digital infrastructure can foster self-reliance and sovereignty while simultaneously enabling private sector innovation (Desai and Manoharan, 2024). This innovation delivers value to citizens and drives a more inclusive economic growth, benefiting society as a whole.

Fig. 2 – Digital Public Infrastructure Framework

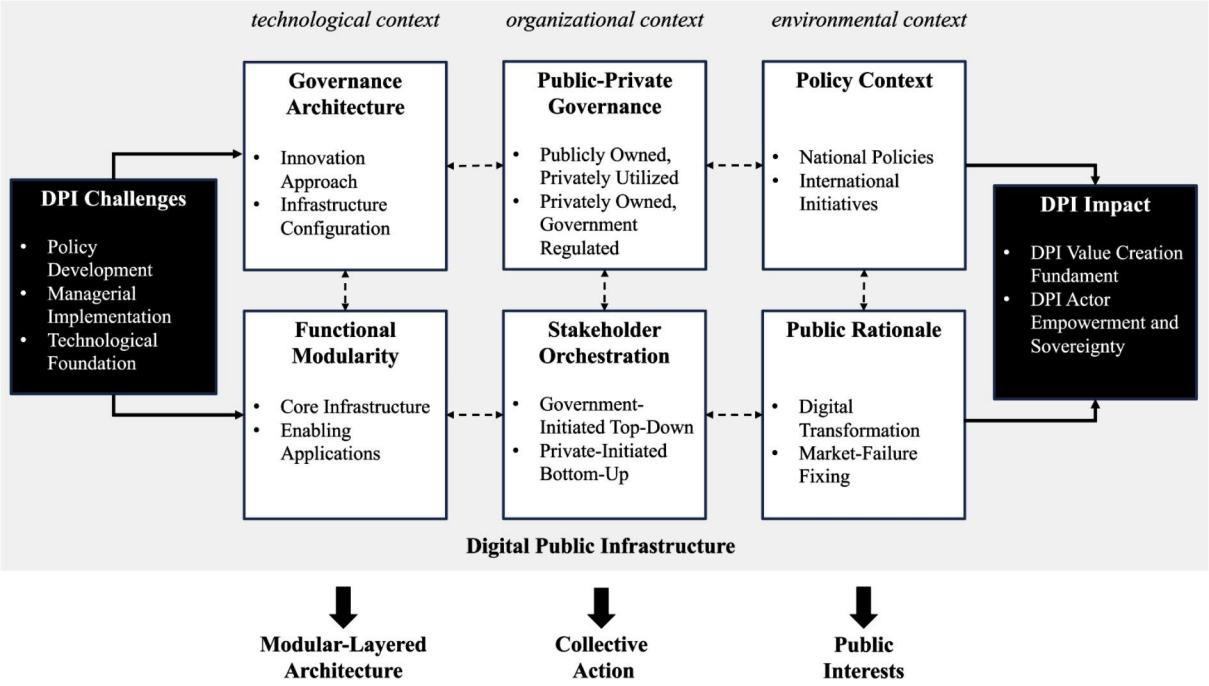


Figure 2 presents our DPI framework, highlighting the key characteristics of DPIs from technological, organizational, and environmental perspectives, and summarizes challenges faced in generating meaningful impact.

5. Discussion

DPI represents an emerging concept advocated especially by governments, international organizations, and philanthropic entities to reimagine the foundational digital frameworks that underpin public and private value creation (Panagiotopoulos et al., 2019; Zuckerman, 2020). DPI aims to facilitate seamless interactions among governments, citizens, and organizations, driving the evolution of digital infrastructures (UN Development Programme, 2023b). To function effectively as a socio-technical system with modular, layered architecture, DPIs must be governed through public–private collective action that embeds public-interest principles into their design and operation. Key imperatives include openness, interoperability, accountability, and inclusive access to ensure value creation and scalable multi-actor engagement in the public interest (Mensah, 2024).

From a technical perspective, standardization and interoperability represent challenges in establishing the foundational infrastructure required for the public-private, modular, and layered nature of DPIs. Given global discourse and necessity for interoperability across countries, achieving global standardization becomes a prerequisite for DPIs. While research on standardization, collaboration, and adoption of infrastructure standards is well-established in fields like information systems (Hanseth and Monteiro, 1997; Tilson et al., 2010), the

scale and global context of DPIs demand an extension of this knowledge. For example, there is a need to investigate processes and challenges associated with DPI standardization, as well as collaboration dynamics among diverse stakeholders.DPIs may necessitate the development of entirely new standards, which highlights the importance of research focused on the barriers to adopting such standards, strategies for overcoming these obstacles, and the role of international organizations and institutions in promoting standardization initiatives (such as the DPI Safeguards working group). Third, the politicization of standards—shaped by national interests, geopolitical tensions, and power dynamics—requires critical study to understand its impact on standard creation and diffusion(Blind, 2025). Technical standards and interoperability are essential in upholding the open and inclusive nature of DPIs, ensuring they remain accessible, adaptable, and capable of fostering value creation.

From a managerial perspective, aligning and orchestrating multiple actors and stakeholders present hurdles to developing, launching, and operating DPIs. Orchestration requires alignment of efforts among governments, private sector, and civil society to establish shared objectives and pool resources efficiently (Hermes et al., 2022) Furthermore, DPIs are not static; they evolve through dynamic processes and generative, reinforcing mechanisms driven by interaction with the using actors (Constantinides et al., 2018; Henfridsson and Bygstad, 2013). Consequently, orchestration emerges as a central managerial capability for DPIs. A critical area for further exploration is how to balance inherent tensions in DPI governance and management. These include reconciling control with fostering innovation, ensuring security while promoting actor acceptance, and aligning public interests with private value creation (Degen and Teubner, 2024; Panagiotopoulos et al., 2019). Furthermore, developing DPIs demands significant upfront investment, but their adoption and generative evolution can create opportunities for reinvestment as utilization increases (Constantinides et al., 2018; Scott et al., 2016). However, identifying sustainable financing models remains a challenge. Hybrid investment strategies that leverage existing components, promote reuse, and foster shared open-source development offer a promising pathway to reduce the financial burden on individual actors through collaborative efforts. Research should focus on identifying frameworks and strategies to effectively navigate these tensions and challenges.

From a policy perspective, our results highlight the need to consider the evolving context surrounding the technical and organizational embedding of DPIs, whose development, implementation, and governance are co-shaped by expectations and discourse around them. Consequently, multilateral cooperation is indispensable for aligning initiatives across regions and sectors. International organizations, e.g. the UN Development Programme (UN Development Programme, 2025), and agreements, e.g. UN Global Digital Compact (United Nations, 2025), play a key role in facilitating dialogue, establishing shared norms, and fostering collaboration among governments, public, private and civic stakeholders, and academia. Achieving harmonization requires striking a balance between concerns over privacy, security, and sovereignty with needs for collective action. However, a "one-size-fits-all" approach to DPIs is likely impractical due to the diverse contexts of their origins, designs, and applications. Given that DPIs transcend national boundaries, harmonizing policies and standards is crucial for ensuring interoperability and equitable access (UN Development Programme, 2023b). Divergent regulatory frameworks often lead to fragmented policy objectives and implementations, undermining the foundational character of these digital infrastructures. While high-level policy goals such as inclusiveness, openness, privacy, and security are widely endorsed, their practical operationalization and prioritization within specific contexts pose significant challenges. The policy context and public rationale for DPIs highlight their dual role: DPIs are envisioned to provide foundational infrastructure capabilities, such as identity, data exchange, and payments, to accelerate the digital transformation of governments, the private sector, and society. At the same time, they have to address diverse objectives, including value creation and digital inclusivity.

Furthermore, ongoing debates about DPIs reveal a shift from a passive regulatory role of governments in the digital realm and their increasingly active provision of digital infrastructures and services designed to reshape markets and actor interactions. The example of traditional infrastructures and networked industries demonstrates that, similar to emerging DPIs, governments have historically played a critical role in ensuring that essential infrastructure services are available to society (Finger and Montero, 2023; Hermes et al., 2022) Additional research should explore which emergent patterns might be identifiable to further conceptualize DPIs and help practitioners grasp this emerging concept. DPIs overlap with various emerging concepts in practice, such as GovTech (Bharosa, 2022), Government-/Countrystack (e.g. EuroStack), Government as a Platform (Cordella and Paletti, 2019), and calls for greater digital sovereignty (Couture and Toupin, 2019) through data spaces and data ecosystems (Möller et al., 2024) as well as the need to address existing digital divides (Vassilakopoulou and Hustad, 2023). This research set out to unpack the conceptual ambiguity surrounding DPIs by grounding the analysis in a structured socio-technical empirical perspective. Through the application of the

TOE framework, the study moves beyond the existing policy discourse to offer a deeper understanding of how technological design, organizational orchestration, and policy environments interact in shaping DPIs. In doing so, it offers a holistic view of DPIs as evolving digital infrastructures that deliver foundational capabilities through public-private collaboration aligned with the public interest.

6. Conclusion and Outlook

Digital public infrastructure (DPI) aims to reimagine foundational digital infrastructures with large-scale societal impact through public-private collaboration, guided by governance that integrates public interest principles—such as openness, interoperability, accountability, and inclusivity—while addressing technological, organizational, and environmental dimensions to ensure societal impact (UN Development Programme, 2023b). By systematically applying the TOE framework to examine the technological, organizational, and environmental dimensions of DPIs, we develop a DPI framework that offers conceptual clarity and a structured approach to understanding and advancing this emerging phenomenon (Awa et al., 2017; Baker, 2012). Positioned as socio-technical systems governed through collective action, DPIs hold the potential to deliver scalable, modular, and public interest-driven digital infrastructure capabilities. With foundational infrastructure components such as digital identity, data exchange, and digital payment systems, DPIs enable value creation and collaboration among diverse actors that aim to serve society.

Our findings show that DPIs encompass governance architecture and modular functionalities within the technological dimension, supported by public-private governance and effective stakeholder orchestration within the organizational dimension. In the environmental dimension, we sketched the motivations driving government engagement and the regulatory context surrounding DPIs. Key objectives include advancing the digital transformation of governments, economies, and societies, alongside addressing market failures that result in under-served groups (e.g., lack of digital inclusion) or power imbalances (e.g. between users and private digital infrastructure providers) caused by privately governed digital offerings. DPIs aim to empower interacting actors by enhancing access rights, safeguarding privacy, and strengthening sovereignty to serve more common public interests. To achieve this, standardization and interoperability are important factors in the technological dimension, while orchestration becomes the critical capability to initiate, adopt, and scale DPIs. In the environmental dimension, which encompasses regulations and policy goals, it is crucial to clearly define the boundaries of policy initiatives and regulatory scopes to avoid fragmentation and conceptual overlap with related terms like DPGs, GovTech, or data spaces and ecosystems. A well-defined DPI concept enhances the alignment and orchestration of relevant stakeholders, enabling the establishment of the capabilities required for DPIs to provide essential infrastructure capabilities to public, private, and civic actors.

Our study comes with limitations. First, the development of our DPI framework is based on the authors' analytical and coding capabilities, providing an initial conceptualization of DPIs within academic research. While this contribution advances both scholarly and practice-oriented discourse, it is subject to potential biases in the analysis. For instance, all authors reside and engage with DPI-related initiatives primarily in the Global North. This perspective enables deep insights but may inadvertently overlook environmental and contextual differences, as DPIs are particularly prominent in the Global South, where they operate under distinct socio-economic and political conditions. Second, while our grounded theory research design draws extensively from academic literature and publications by international organizations, think tanks, and philanthropic entities, it relies on secondary data often optimized to promote the concept of DPIs to a broad, international audience. To address this limitation, we plan a follow-up research project involving qualitative interviews with diverse experts recruited to represent public, private and civic stakeholders. This approach will enable us to extend upon our insights into DPIs, uncovering differences and commonalities across geographical, socio-economic, and political contexts, while addressing the limitations of our study.

DPIs are a timely and emerging concept that seeks to address multiple societal transformations and current challenges. Our study underscores that DPIs are highly context-specific, and a "*one-size-fits-all*" approach is not possible. These large-scale digital infrastructures not only shape societies but are also deeply influenced by them. We call for interdisciplinary research to examine DPIs across varied contexts and across implementation phases. Based on our academic literature review, we urge researchers and practitioners to view DPIs not as entirely novel phenomena but as an evolution of existing digital infrastructures and platforms. DPIs should be characterized as a progression toward more open, interoperable, and accountable foundational capabilities for public-interest value creation.

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