

Rethinking Value in Digital Public Infrastructure

A Framework for Value by Design DPI

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Executive Summary

This report maps the evolving global landscape of Digital Public Infrastructure (DPI), using case-based analyses to offer an iterative approach to designing, implementing, and measuring DPI initiatives for more effective service delivery.

Digital Public Infrastructure (DPI) is increasingly shaping how governments and societies deliver core public services, facilitate civic participation, and unlock economic opportunity. As the global conversation around DPI gains momentum, there is a growing need to assess how such infrastructure can be developed, implemented, and scaled in ways that maximize public value.

This report makes **four key contributions** to this effort. First, it **assesses the current global landscape** of DPI, identifying gaps in prevailing frameworks and highlighting the need for a more holistic, outcome-oriented approach. Second, it introduces a **new Value by Design framework** to guide DPI development. Third, it applies this framework to **eight case studies**, to evaluate diverse DPI implementations across political, economic, and institutional contexts. Fourth, it distills the cross-cutting lessons from these cases into a **set of core principles** to inform future DPI design and execution.

The cyclical framework comprises four phases: **Define, Identify, Implement, and Measure**.

Define: Actors articulate clear, citizen-centric value propositions, outlining specific societal outcomes they aim to achieve through DPI initiatives.

Identify: Actors assess factors such as infrastructure readiness, institutional capacity, market conditions, and levels of trust and digital

literacy to highlight strengths and pinpoint institutional roadblocks.

Implement: Actors build DPI applications that increase interoperability, transparency, privacy, and collaboration across public and private sectors.

Measure: Actors evaluate the extent to which DPI initiatives have achieved their defined goals through rigorous impact assessments focused on human-centered outcomes.

Based on these evaluations and outcomes, actors use the measurement phase to redefine their strategic objectives, incorporating lessons learned to enhance future DPI effectiveness. The **VbD framework's iterative structure** facilitates continuous evaluation and improvement, allowing institutions to build more resilient and effective DPI over time.

This framework was refined through the analysis of eight carefully selected case studies, chosen to reflect a diverse mix of **regional contexts, success trajectories, implementation models, and DPI pillars**—including digital identity, payments, and data exchange. Together, these case studies span a range of governance structures and maturity levels, offering insights from both public- and private-led initiatives. They highlight the critical enablers that allowed some projects to succeed, and the barriers that limited the long-term impact

of other initiatives, providing a rich evidence base to inform and strengthen the framework.

As DPI development continues to grow, it is essential to center citizen value through the DPI

lifecycle. This framework equips institutions with an adaptive approach to evaluate, refine, and scale DPI initiatives that truly serve the public good.

The 11 Principles of DPI

Drawing from our case study analysis and application of the Value by Design framework, we identified a set of **eleven cross-cutting principles** that consistently shape the success or failure of DPI initiatives. These principles are not bound to any single country or technology ecosystem—they reflect real-world patterns across diverse political, economic, and institutional contexts. The following section distills these learnings into actionable insights to help guide stakeholders throughout the DPI lifecycle.

- 1. Build trust through various channels.** Trust in government, trust in data security, or trust in the private sector can each impact DPI development differently. Each facet of trust matters, but none are prerequisites for successful DPI. Rather, deficiencies in one aspect of trust may highlight a specific DPI development strategy.
- 2. Leapfrog DPI building blocks.** Traditional success stories followed a more structured—data exchange, then ID, then payments—but there are ample examples of countries successfully leapfrogging basic building blocks and going directly for payments.
- 3. Be the first-mover.** As with other digital services, DPI provides more value as more people use it, making it progressively harder to stray away from what was initially built. First-mover advantage is key, forcing nascent DPI initiatives to always be aware of what alternative services have to offer.
- 4. Foster strong leadership for DPI's long term success.** Leadership need not be from the public sector, but adequate buy-in from institutions with the power to coordinate across partnerships will determine the ultimate outcomes. State-level initiatives should be aligned with national strategies to help secure support.
- 5. Use regulation to support scale.** Though successful stories have been created without direct government involvement, government oversight is necessary to scale-up initiatives. Policies (e.g. data protection, competition, cybersecurity) provide legal stability for private and public agents, creating a more secure playing field for DPI initiatives to thrive.
- 6. Attract and retain technical expertise to run a state-led DPI operation.** Effective DPI development relies on strong collaboration between government institutions and private-sector innovators. Successful cases of state-led DPI development have one thing in common: local teams well-versed in the technical requirements of building DPI. When local technical expertise is absent, governments

can struggle to scale-up pilots developed by the private sector.

7. Embed Interoperability from the outset as a core design principle rather than retrofit it later.

This ensures that digital public infrastructure can scale effectively, support cross-sector integration, and avoid fragmentation beyond initial pilot deployments.

8. Encourage international collaboration along all maturity levels.

While some countries have developed their own infrastructure first and then scaled it up to include other nations (e.g. India and Singapore), others have found international collaboration to be essential from the get-go (e.g. Kenya, Mexico, South Africa). When international collaboration happens at the start, however, it is fundamental to have clarity on what the local context is.

9. Ensure DPI is financially sustainable. As with any other infrastructure project, DPI is heavily

dependent on budgeting, both for financing and maintenance. Budget constraints can be addressed during different phases of DPI development.

10. Deploy DPI in phases. Before committing to a specific system design, test it. A phased approach allows for players to adjust their course and deliver value without incurring major risks. Once the main DPI systems are in place, institutions should divert efforts and attention towards maintaining them, ensuring services are reliable and trusted.

11. Be ready for the next frontier of DPI. As institutions and citizens experience the value of digital infrastructure, new initiatives are being built to expand the benefits DPI can bring, both locally and globally. Players should be ready to adapt what they have already built to a new set of services.

Moving forward, this Framework requires promotion and use to ensure its propagation throughout the DPI community. It is only through socialization and iterative adjustments that its value can be maximized, contributing to a growing global DPI discussion. Future work should seek to:

- **Socialize the Framework** to key stakeholders and major champions of DPI.
- Develop an accompanying **DPI Maturity Model**.
- Refine the Framework via a series of **“VbD Framework in Action” reports**.
- Compile a **centralized knowledge-base** of global DPI initiatives.

As the global conversation around DPI evolves, the World Economic Forum is uniquely positioned as both a convener and catalyst for DPI efforts rooted in public value. In doing so, the Forum can take a leading role in shaping inclusive, future-proofed DPI worldwide.

1. Background

Digital Public Infrastructure is still a nascent concept, with diverse use cases, analytical approaches, and frameworks for success. Developing a shared understanding of DPI can allow for more successful DPI projects in the future.

1.1 What is DPI?

In an increasingly digital world, the resilience and core functioning of governments and societies depend on the systems we build to facilitate access to key services. Digital Public Infrastructure (DPI) refers to a foundational set of digital capabilities that facilitate the delivery of services at scale across public and private sectors ([World Bank, 2023](#)). In the wake of the COVID-19 pandemic—when digitization became a critical component for safe and efficient service delivery—governments, international organizations (IOs), and non-governmental organizations (NGOs) began formalizing a definition for DPI. This culminated in the G20 recognition of DPI as a “set of shared digital systems...to deliver and provide equitable access to public and/or private services at societal scale” ([G20, 2023](#)).

While implementation approaches vary, consensus has coalesced around three foundational pillars:

- Digital identity: Systems that enable individuals and businesses to verify and authenticate their online identities to access public services.
- Digital payments: Infrastructure that facilitates seamless, secure, and real-time transactions.
- Data exchanges: Platforms that support the flow of information across government, citizens, and the private sector.

Together, these pillars serve as the backbone of inclusive digital service delivery, enabling more efficient governance, economic participation, and civic engagement.

Formal definitions of DPI are quite new, with significant variations in how stakeholders conceptualize and approach digital public infrastructure ([OECD, 2024](#)). Some interpretations emphasize state ownership and control to protect sovereignty, while others advocate for more flexible approaches involving public-private partnerships and open ecosystems. These differences in understanding create potential challenges for cross-border compatibility and knowledge sharing as the global conversation around DPI evolves. Nevertheless, public and private sector actors across the world have been implementing what we now recognize as DPI projects for decades. Estonia’s X-Road data exchange platform, launched in 2001, has enabled secure interoperability across government and private systems, representing a predominantly government-led approach. Singapore introduced SingPass in 2003, allowing residents to

verify their identity and access multiple digital services through a model balancing government oversight with private sector integration. In 2007, a private partnership between telecommunications, banking, and micro-lending companies in Kenya resulted in M-Pesa, a digital payments solution that revolutionized mobile transfers and demonstrated how private-sector innovation can deliver transformative digital infrastructure. These earlier instances of DPI development illustrate how diverse governance traditions can successfully implement digital infrastructure while maintaining core principles of interoperability, accessibility, and public value ([Digital Impact Alliance, 2024](#)).

Functionally, DPI applications consist of building blocks like Digital Public Goods (DPGs), a standard for open-source software designed in the interest of public good ([Digital Public Goods Alliance, 2022](#)). Governments may rely on DPGs and private sector solutions alike to develop their digital infrastructure. Unlike DPGs, DPI applications have no standards or licensing requirements, contributing to the broad understanding of what constitutes DPI ([Digital Public Goods Alliance, 2022](#)). This diversity underscores both the potential and the complexity of DPI, reinforcing the need for frameworks that guide development toward measurable public value.

1.2 Who is this report for?

This report is designed to serve a diverse array of stakeholders involved in the development, implementation, and governance of DPI:

- **Policymakers and Government Stakeholders** will find the Value by Design framework helpful in setting clear objectives for DPI initiatives and ensuring they deliver meaningful public value beyond technological implementation.
- **International Organizations and Development Partners** can use the VbD principles and case studies to inform their support strategies for countries at different stages of DPI development.
- **Private Sector Innovators** will benefit from insights into successful collaboration models that balance market-driven innovation with inclusive access and public interest considerations.
- **Civil Society Organizations** will find our emphasis on citizen-centric design and inclusive approaches relevant to their advocacy for equitable digital transformation.
- **Multilateral Forums and Regional Bodies** can draw on our findings to develop shared understandings of DPI that respect diverse governance traditions while enabling cross-border collaboration.

The framework and principles presented are informed by consultation with experts, academics, and practitioners from across the DPI ecosystem, including public sector leaders, cybersecurity specialists, and researchers from leading academic institutions. The goal of this report is to provide practical

guidance for anyone working to ensure that digital infrastructure genuinely serves the public good, regardless of the specific implementation approach.

1.3 Contextualizing the Value-Based Framework

The fragmented and evolving nature of Digital Public Infrastructure (DPI) presents significant challenges for conducting systematic impact evaluations. As highlighted during the 2023 G20 Summit, global stakeholders have only recently begun developing widely accepted definitions of DPI, let alone frameworks for successful DPI development and implementation. **This report aims to address that gap by analyzing the current landscape of DPI research and identifying under explored aspects of the DPI-discourse.**

1.3.1 CURRENT STATE OF DPI ANALYSIS

There has been rapid growth in the development of frameworks and analytical approaches. These efforts span a variety of methodologies and focal areas: emphasizing technical implementation, growth measurement, and sector- or country-specific case studies. While these approaches have laid a valuable foundation, there remains an opportunity to more explicitly connect DPI success to public value and offer actionable insights across global contexts.

- [Technical Architecture and Implementation](#)

Much of the existing DPI analysis focuses on the technical architecture and deployment of DPI systems. These frameworks offer valuable insights into building DPI systems and establishing the necessary technological foundations.

For instance, the World Bank's Identification for Development (ID4D) and Digitizing Government-to-Person Payments (G2Px) initiatives have supported over 60 countries in issuing inclusive, secure, and user-centered digital IDs, while offering downloadable implementation guides used globally ([World Bank, 2025](#)). Similarly, the UNDP has created technical roadmaps for countries implementing DPI, with a particular focus on promoting open source technology and global ecosystems of digital public goods ([UNDP, 2025](#)). Their implementation frameworks emphasize interoperability, security, and openness as key technical principles.

Think tanks and academic institutions have also advanced implementation insights. Carnegie India's "DPI as a Packaged Solution" (DaaS) model offers pre-configured implementation packages that countries can adapt to local needs rather than building systems from scratch, akin to a "plug-and-play" approach ([Carnegie Endowment, 2024](#)). The OECD's Digital Government frameworks analyze how DPI serves as an enabler for digital government services, examining technical requirements for interoperability between government systems ([OECD, 2024](#)). These frameworks emphasize reusable digital components as building blocks for government service delivery.

While these implementation-focused frameworks are essential for successful DPI deployment, they often position DPI primarily as a technological challenge rather than as a means to achieve specific policy objectives. A critical gap remains in connecting architectural choices to the societal goals DPI is ultimately meant to support.

- [DPI Measurement and Evaluation Frameworks](#)

Existing frameworks have also established important metrics for tracking DPI implementation, focusing primarily on adoption rates, transaction volumes, and macroeconomic outcomes that help gauge system uptake and operational capacity.

However, many of these approaches rely on adoption statistics, transaction volumes, and broad economic indicators rather than metrics that directly capture human impact. Indeed, the mere existence of DPI can often serve as its own key performance indicator (KPI), treating the existence of DPI as a sufficient outcome. These challenges are present across institutions. For example, the OECD’s Digital Public Infrastructure for Digital Governments notes that a primary function of DPI is an “enabler of the ‘Government as a Platform’ model,” which is itself defined as “government services enabled by a core set of reusable digital components” ([OECD, 2022](#); [The OECD Digital Government Policy Framework, 2020](#)). This type of framing risks becoming circular: DPI is treated as successful if it enables further DPI, rather than if it achieves broader developmental outcomes.

Both the Brookings Institute and The Digital Impact Alliance (DIAL) have raised these concerns, noting a lack of comprehensive, outcome-oriented indicators. Their analyses point to fragmented measurement approaches and a prevailing emphasis on scale, which risks overlooking the transformative—or unintended—effects of DPI ([Brookings, 2022](#); [DIAL, 2024](#)). Together, these analyses note that success metrics across all DPI pillars often emphasize adoption and availability metrics, increasing the risk that DPI is evaluated primarily on its reach rather than its transformative impact.

Emerging models are beginning to close this gap. The UCL Institute for Innovation and Public Purpose has developed a public value measurement framework for assessing DPI’s direct, dynamic, and market-shaping impacts across individual, institutional, and societal levels ([UCL, 2025](#)). Likewise, the Center for Strategic and International Studies (CSIS) has analyzed DPI’s influence on sectoral development outcomes, noting that DPI is transforming economies worldwide and can be a powerful tool for reducing poverty and examining sector-specific impacts, such as improved data interoperability in healthcare ([CSIS, 2023](#)).

These emerging measurement approaches represent important progress, but there remains an opportunity to develop more comprehensive frameworks that connect implementation choices directly to human outcomes. More diverse and granular measurement approaches could help policymakers better understand DPI’s multidimensional impact and make more informed design and implementation decisions.

- [National and Sectoral Emphasis](#)

Finally, the current discussion on DPI includes numerous valuable case studies examining specific DPI implementations in particular sectors or regions. These case studies provide rich insights into implementation pathways, technical decisions, and institutional arrangements, but often lack comparative frameworks or transferable lessons.

For example, India’s DPI journey is perhaps one of the most thoroughly documented, with extensive analysis of the “India Stack” comprising Aadhaar (identity), UPI (payments), and DigiLocker (documents). The success of UPI in particular has become a reference point, with analysis of how it has enabled private-sector growth, prevented digital monopolies, and safeguarded rights and freedoms. The analysis typically highlights architectural features, adoption metrics, and technical innovations. Yet, much of the existing impact analysis centers on scalability and infrastructure, with less emphasis on how these systems have improved service delivery or quality of life for India’s citizens.

Moreover, these case studies often remain siloed within specific national or sectoral contexts, lacking a comparative lens that can support cross-country learning or transferability. While some institutions like CSIS have examined approaches to DPI in the Global South, these analyses typically present individual country experiences rather than identifying patterns or transferable principles across regions ([CSIS, 2024](#)). This approach makes it difficult for policymakers to understand which aspects of successful implementations might be relevant to their specific contexts or how regional cooperation might enhance DPI value.

Box 1: GLOBALIZED DPI

Digital Public Infrastructure is increasingly transcending national boundaries through regional and cross-border initiatives that enhance interoperability, efficiency, and shared value creation. The European Union’s Digital Identity Wallet exemplifies a multi-nation approach, creating interoperable digital identification across 27 member states to enable seamless access to public services throughout the region ([European Commission, 2025](#)). Similarly, ASEAN’s Digital Integration Framework demonstrates how regional economic blocs can establish shared standards for digital payments and identity systems despite varying levels of economic development ([ASEAN, 2020](#)). The India-Singapore UPI-PayNow integration represents a bilateral model of success, connecting real-time payment systems between nations with established leadership from central banks and regulatory authorities. This integration reduced transaction costs and has catalyzed India’s expansion to seven countries through Project Nexus, creating a blueprint for cross-border DPI that maintains both national sovereignty and interoperability ([Monetary Authority of Singapore, 2023](#); [NPCI International, 2025](#)). These examples underscore the multiple pathways through which international DPI cooperation can evolve—from bilateral arrangements to multilateral frameworks. In each case, success has hinged on the ability to balance interoperability with sovereignty, creating scalable models that deliver cross-border value while respecting local governance.

While institutions like UCL have begun addressing these gaps by examining how DPI can be governed for the common good ([UCL, 2024](#)) there remains a significant opportunity to develop frameworks that more systematically analyze how DPI creates value both within specific contexts and across regional or global ecosystems. A Value by Design approach would help countries not only implement effective systems locally, but position them within evolving regional and global digital infrastructure.

1.3.2 THE VALUE BY DESIGN APPROACH

A review of the current Digital Public Infrastructure (DPI) landscape reveals a clear opportunity to advance analytical frameworks by placing value creation at the core of DPI development and implementation. While technical specifications, adoption metrics and individual case studies offer critical foundations, they often fall short of linking infrastructure to broader societal objectives. Four key gaps emerge:

First, many frameworks implicitly treat DPI as inherently beneficial, without sufficiently interrogating the underlying purpose or policy goals. This approach risks conflating the completion of technical infrastructure with the achievement of meaningful societal outcomes. A Value by Design approach begins by asking a foundational question of *why* a given DPI initiative should be pursued. It then links that rationale to specific outcomes that serve the public interest, ensuring that digital systems are a means to an end, not the end itself.

Second, most frameworks provide limited guidance on the conditions that enable or inhibit DPI success. Factors such as institutional trust, cybersecurity readiness, digital literacy, and baseline infrastructure are often treated as peripheral, despite their decisive role in shaping DPI effectiveness. A more rigorous, systematic analysis of these contextual variables would support more informed, context-sensitive implementation strategies.

Third, the focus on national DPI systems often overlooks the growing potential of cross-border integration. Initiatives such as the India–Singapore UPI–PayNow linkage illustrate how digital systems can create value across jurisdictions. A globalized perspective allows countries to better align their efforts with emerging regional and international infrastructures, while preserving local priorities.

Fourth, current frameworks often assume static policy goals, underestimating the dynamic environments in which DPI operates. Rapid technological advances, shifting citizen expectations, fiscal constraints and geopolitical considerations all influence DPI relevance over time. **By embedding iteration and feedback into the design process, a Value by Design approach ensures that systems remain adaptive, resilient and citizen-centered.**

To address these gaps, this report introduces the Value by Design framework—a structured approach for guiding DPI development through four interconnected phases: Define, Identify, Implement and Measure. This framework complements existing technical guidance by prioritizing the delivery of public value and supporting policymakers in translating infrastructure investments into tangible societal benefits.

2. Conceptualizing the Value by Design Framework

Developing Digital Public Infrastructure through a Value by Design Framework.

Building on existing DPI research, this report introduces the Value by Design framework—a four-phase model through which countries can structure and assess their DPI journeys. The framework, conceptualized in Figure 1, introduces four phases: Define, Identify, Implement, and Measure, with each phase building upon the previous one to create a dynamic feedback loop that helps governments continuously refine and improve their digital transformation strategies.

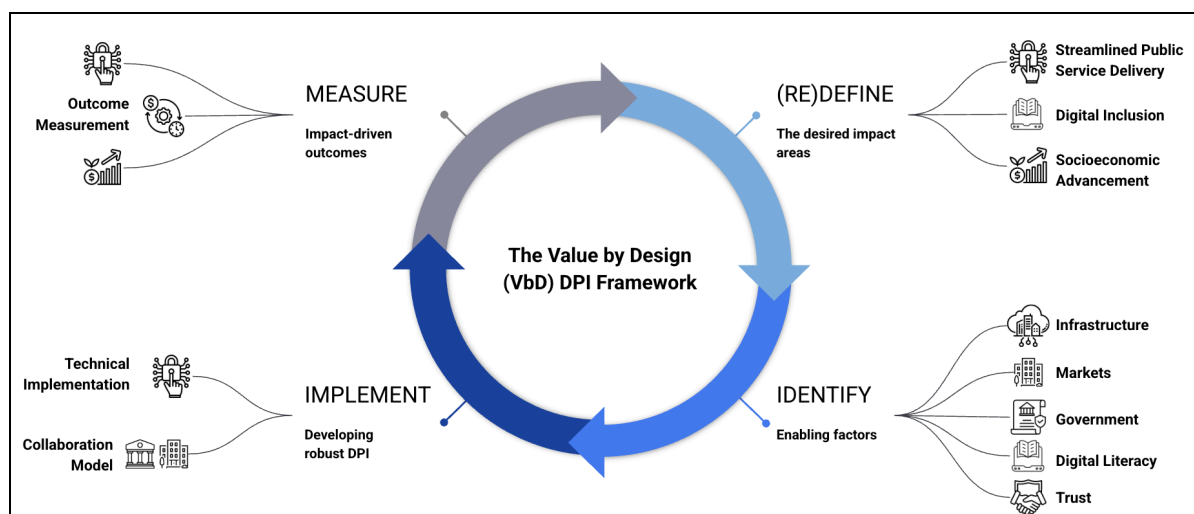


Figure 1: Conceptual Model of the Value by Design (VbD) DPI Framework

2.1 Methodology

The development of the Value by Design framework was grounded in a multi-pronged methodology designed to integrate existing insights, test conceptual assumptions, and validate practical relevance across diverse contexts. Key steps included:

- **Synthesizing existing frameworks:** We analyzed technical implementation frameworks from the World Bank’s ID4D and G2Px initiatives, governance-oriented frameworks from UCL, and the UNDP’s Digital Development Compass. This comparative review helped identify complementary elements as well as conceptual and operational gaps.
- **Enhancing dimensional analysis:** To move beyond binary evaluations (e.g., “Do cybersecurity guardrails exist?”), we introduced a tiered approach that reflects varying levels of institutional maturity—ranging from basic to transformational DPI implementations.
- **Case study application:** We piloted the initial version of the framework across a set of diverse national contexts, including Estonia’s X-Road platform, the India–Singapore UPI–PayNow integration, Brazil’s PIX system, Mexico’s interoperability infrastructure, Kenya’s M-Pesa platform,

and Saudi Arabia’s digital government programs. These cases span different governance models, regional dynamics, and DPI pillars.

- **Value-centered outcome measurement:** Insights from the case studies were used to sharpen the framework’s focus on outcomes—strengthening the link between value definition, enabling factors, implementation practices, and societal impact.
- **Expert validation:** Throughout the process, the framework was refined through consultations with practitioners and experts across sectors. These included public sector leaders in France and Saudi Arabia, cybersecurity experts at Google, and researchers from leading academic institutions.

The resulting framework offers a structured, Value by Design approach to DPI development that places public value at the center. It aims to help policymakers move beyond infrastructure deployment to ensure DPI serves as a vehicle for inclusive, measurable, and human-centered outcomes. The following sections present the framework in detail, illustrating how it can guide countries through the four phases of defining purpose, identifying enablers, implementing with integrity, and measuring citizen impact.

2.2 The Four-Phase Value Cycle

2.2.1 DEFINE

Establishing Purpose and Value

The Define phase marks the strategic starting point of a country’s DPI journey, grounding digital transformation in a clear articulation of public purpose and clarifying the intended outcomes of the infrastructure. Rather than a one-time step, value definition is part of an ongoing feedback loop, allowing governments to revisit and refine priorities in response to evolving citizen needs, policy shifts, and impact assessments.

In this phase, high-level aspirations are translated into concrete outcomes grounded in real-world challenges. Effective DPI strategies begin by identifying pressing societal needs and defining how digital tools will be used to address them—not as endpoints, but as levers for better governance, empowerment, and equity.

Linking Vision to Outcomes: At its core, this phase is about setting goals that are measurable, meaningful, and aligned with public value. These goals should be informed by empirical data, user research, and participatory engagement. They should explicitly link digital actions to broader societal outcomes, such as economic empowerment, civic participation, or institutional trust. Finally, the country should be able to build a comprehensive measurement framework that blends key performance indicators (e.g., user adoption, service access rates, satisfaction metrics), lagging indicators (e.g.,

long-term economic mobility, health or education outcomes), and unexpected impacts, both positive and negative.

Areas of impact: While value propositions will vary by context, DPI initiatives commonly target one or more of the following outcomes:

A. Socioeconomic Advancement

DPI can enable a broad range of socio-economic goals, such as inclusive economic growth and civic empowerment. For example:

- **Enhancing local entrepreneurship**, innovation, and job creation.
- **Expanding financial inclusion** and creating mechanisms for increasing financial transactions within and between countries.
- **Increasing civic engagement** and participation in government.

B. Streamlined Public Service Delivery

DPI can simplify how citizens interact with the public sector by decreasing government expenditures and increasing access to welfare services. For example:

- **Enabling seamless integration across government systems** to provide services through unified, user-centric platforms.
- **Reducing administrative burden** by applying the “once-only” principle—where citizens submit information just once and it flows securely across departments.

C. Digital Inclusion

DPI can address structural barriers to digital access, including cost, literacy, language, disability, and geographic location. For example:

- **Increasing outreach** for the hardest-to-reach populations, including offline-to-online bridges and assisted access points.
- **Addressing disparities in digital usage** and service uptake, disaggregated by gender, income, age, geography, and other social markers.

These categories are neither exhaustive nor mutually exclusive. Improvements in digital inclusion can unlock economic opportunity, just as more efficient public services can expand access and build trust. Governments are encouraged to define value in ways that reflect local conditions while remaining adaptable to emerging needs.

Importantly, value should be framed in terms of the societal outcomes DPI enables, not the infrastructure itself. Success lies not in the deployment of systems, but in their contribution to more equitable, efficient, and resilient public services.

2.2.2 IDENTIFY

Assessing enablers and bottlenecks

Once goals are clearly defined, the next step in the VbD frameworks is to assess the foundational conditions that will shape implementation. This “Identify” phase provides a critical baseline from which strategic decisions about implementation can be made. It allows countries to pinpoint strengths, uncover bottlenecks, and understand where targeted interventions are most needed.

Our framework organizes the enablers into five interdependent categories: Trust, Government, Markets, Infrastructure, and Digital Literacy. Each must be analyzed in depth, using both qualitative and quantitative methods. These elements interact in complex ways depending on national context, and while none are strict prerequisites, each contributes uniquely to the success and sustainability of DPI initiatives.

Countries should strive to develop each of the proposed enablers, but in no way do they represent roadblocks for DPI development. The aim is not to enforce a fixed sequence of readiness, but rather to surface patterns and dynamics that inform effective strategy, enabling policymakers to prioritize and adapt accordingly.

- [Trust: Building the foundations of confidence in digital systems](#)

Trust is a foundational requirement for any DPI ecosystem, spanning user confidence in security, privacy, accountability, and institutional integrity. This trust must be actively cultivated across six dimensions:

- **Cybersecurity:** A national cybersecurity framework should include clear legal mandates, technical standards, mandatory compliance protocols, and alignment with international norms.
- **Data Protection:** Enforceable data protection laws should safeguard citizen privacy, while open data practices enhance transparency and utility of non-sensitive public information.
- **Standards of Responsibility:** DPI design should prioritize privacy, transparency, and accountability, protections underpinned by evolving ethical standards and stakeholder engagement.
- **Consumer Protection:** Independent regulatory oversight, sector-specific rules, and mechanisms such as price transparency are vital to ensure users are not exploited in digital service markets.
- **Human Rights:** DPI should embed civil liberties protections across legal, technical, and institutional frameworks—ensuring that digital systems uphold, rather than undermine, rights.
- **Open Source and Standards:** Adopting an “open by default” approach, either through source code transparency, technology neutrality, or collaborative ecosystems, can help avoid vendor lock-in and build long-term public trust.

- [Government: Ensuring institutional capacity and integrity](#)

A strong and ethical state is a critical component for DPI development and sustainability. Governments must assess their institutional readiness across four critical areas:

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- **Leadership and Strategy:** There should exist a clear strategy with strong high-level political support. Leaders should be empowered with operational authority and accountability to drive digital transformation onward.
 - **Implementation Capacity:** DPI Implementation requires cross-sectoral coordination, skilled digital professionals, a long-term funding strategy, and institutional backing by agencies that can monitor and course-correct in real time.
 - **Open Government:** Governments should emphasize transparency and inclusiveness, creating formal channels for stakeholder engagement, data access, and co-creation of public services.
 - **Anti-Corruption Controls:** Corruption is at the heart of government inefficiency. As such, governments should establish a robust anti-corruption architecture: independent mechanisms for victims of corruption, legal protections for whistleblowers and anti-corruption actors, and transparent budgeting processes with active legislative oversight. These controls enhance both system integrity and citizen trust.

- [Markets: Fostering dynamism and innovation](#)

The private sector plays a central role in the DPI ecosystem, from infrastructure development to service innovation. Dynamic markets rely on:

- **Private Sector Readiness:** Businesses should be digitally enabled, with clear policies fostering public-private partnerships and interoperable digital ecosystems.
- **Innovation Ecosystem:** Countries should promote research and development via cross-sector collaboration, global linkages, and a strong pipeline of IT professionals through research grants, innovation hubs, and entrepreneur networks.
- **Fair Market Competition:** Regulatory frameworks should ensure competitive neutrality, including anti-monopoly provisions, IP protections, adaptive taxation, and efficient dispute resolution mechanisms.

- [Infrastructure: Laying the groundwork for widespread access](#)

Digital infrastructure inherently relies on physical infrastructure. Aspects such as electricity, internet, mobile, and cloud coverage are fundamental to support scalability and reliability. Key dimensions include:

- **Physical Infrastructure:** Broadband, mobile networks, cloud infrastructure, and device accessibility should be widespread and resilient to support scalable DPI systems.
- **Access Enablers:** Policymakers must proactively remove structural barriers, addressing disparities in affordability, geography, gender, and ability to ensure that no group is excluded.

- [Digital Literacy: Building capabilities and civic engagement](#)

Digital literacy is the bridge between infrastructure and impact. The framework calls for assessment of digital capabilities across four dimensions:

- **Usage and Adoption:** A population that has historically been able to access and use digital services (not necessarily public ones) is also a population with better chances of extracting value from DPI. Governments should identify the usage divide that persists even after the infrastructure is in place.
- **Skills and Education:** DPI readiness requires digital literacy - not only in schools but also through adult education centers, workplace retraining, and public campaigns.
- **Cultural Norms:** A national discourse that promotes a culture of digital innovation empowers its citizens to use technology confidently, responsibly, and creatively.
- **Civic Engagement:** When civic engagement is present - through digital civic platforms, inclusive public debate, and independent media - users can better leverage the services provided by DPI and are better equipped to participate in its governance.

Box 2: Prerequisites for DPI Implementation

DPI has the potential to significantly enhance citizen convenience, improve the efficiency of public service delivery, and promote social inclusion. However, not all countries or regions are immediately positioned to undertake DPI initiatives. Without certain foundational conditions in place, DPI projects may face operational failure—or worse, exacerbate existing inequalities and governance challenges.

Outlined below are four key prerequisites that should be carefully considered before embarking on DPI implementation:

- **Fulfillment of Basic Living Conditions**

In contexts marked by humanitarian crises—such as widespread hunger, armed conflict, or natural disasters—citizen priorities are rightly centered on survival and access to essential services like food, water, healthcare, and security. In these cases, DPI should be viewed as a longer-term objective, appropriate only once foundational needs are stabilized and core infrastructure is restored.

- **Security and Political Stability**

The sustainable development and governance of DPI requires a degree of political stability. In environments characterized by frequent leadership turnover, civil unrest, or institutional fragility, DPI planning and implementation become extremely difficult. Without basic public security, even physical infrastructure remains vulnerable to disruption.

- **Institutional Capacity and Legal Foundations**

DPI must be built on a basic level of administrative capacity and legal infrastructure. In the absence of a functioning civil registry or national ID system, introducing digital identification is impractical. Similarly, if a country lacks laws on data protection and digital governance, DPI may expose citizens to

serious risks, such as privacy violations or state surveillance. Institutional trust and legal safeguards are essential prior to implementation.

- Financial Sustainability and Support Mechanisms

While DPI development and maintenance require financial resources, international organizations (e.g., the World Bank, UNDP) and donor countries can provide significant support. Thus, full self-funding is not necessarily required. However, a sustainable financial strategy and institutional framework must be in place to ensure long-term viability. Overdependence on external aid can undermine the system's future sustainability and resilience.

Recognizing and progressively addressing these preconditions is a critical step toward the successful and impactful deployment of DPI.

[Data Sources](#)

While accessing each of the various enabling factors mentioned above, a country could use as data sources:

- Official national/local public data
- [The UNDP Digital Development Compass](#)
- [The NCSI Cybersecurity Index](#)
- [Digital Government Readiness Assessment \(DGRA\)](#)

2.2.3 IMPLEMENT

Building the Execution Structure

The implementation phase translates a country's DPI vision into operational reality. It establishes how systems are built, who leads their development, and what standards ensure their trustworthiness, security, and inclusivity.

This phase comprises two core components:

- **Technical Implementation:** the design principles and safeguards needed for effective DPI operation.
- **The Collaboration Model:** a typology of governance structures that defines the roles of government, private actors, and civil society in DPI delivery.

While clearly defined goals are essential, implementation requires actionable pathways that align those goals with execution. Without this alignment, DPI risks falling short of its public value objectives. This phase therefore acts as a critical bridge—moving from intent to impact.

Additionally, both the technical requirements and the Collaboration Model are assessed across three levels of maturity: Basic, Systematic, and Transformational. This tiered approach enables countries to benchmark progress and plan strategic evolution over time.

[Technical Implementation](#)

Effective technical implementation ensures that DPI systems function securely, reliably, and equitably under real-world conditions. It translates high-level design principles into operational systems that serve users at scale. Effective technical implementation requires a clear architectural vision, robust infrastructure, and adherence to standards that enable interoperability, trust, and inclusion, and resilience to disruptions such as cyberattacks or major system failures. Four dimensions are foundational:

- **Interoperable and Extensible:** DPI systems must facilitate seamless data exchange through shared standards, APIs, and modular architecture. This enables secure integration across services, supports authentication, and allows for future scalability. Transparency in documentation and adherence to international norms prevent vendor lock-in and promote long-term innovation.
- **Transparency, Accountability, and Oversight:** DPI must provide visibility into its operations. Mechanisms such as real-time monitoring, transaction tracking, public information access, and third-party audits help reinforce accountability, improve responsiveness, and build trust with users.
- **Privacy, security, and protection:** Systems must safeguard user data and defend against misuse and cyber threats. Core features include access controls, breach detection, encryption, and incident response protocols. Advanced systems may deploy AI-based threat analytics and resilience architectures to reinforce public confidence.
- **Non-discrimination and inclusion:** DPI should be accessible and equitable by design, regardless of ability, background, or connectivity. This includes accessible design, multiple service channels, responsive user support, and proactive inclusion strategies. Inclusive systems anticipate diverse needs, ensuring no one is left behind.

[Collaboration Model](#)

The Collaboration Model defines who leads and how roles are distributed in DPI implementation. While technological implementation determines how DPI functions, collaboration clarifies who builds, operates, and governs it. Based on global practice, three primary configurations emerge:

- **Government-led:** The state leads end-to-end design and implementation. At advanced stages, government institutions coordinate across agencies and serve as platform enablers—establishing infrastructure that others build upon. Private sector involvement may be limited to advisory or supportive functions.

- **Non-Government-led:** DPI implementation is led by non-governmental actors such as technology companies, NGOs, or multilateral organizations. In early stages, the public sector may define broad requirements or act as a convenor. In more mature models, private and civil society actors take on operational leadership, often in areas of innovation, outreach, or specialized infrastructure.
- **Hybrid:** A shared model where responsibility is distributed through formal partnerships. Early-stage collaborations may be project-based; more mature arrangements involve co-development, integrated teams, and joint governance. This model allows governments to retain strategic control while leveraging external innovation and capacity.

In practice, nearly all DPI efforts require multi-actor collaboration. Public-private partnerships and civil society engagement are not optional add-ons but core enablers of reach, adaptability, and innovation. The Collaboration Model therefore provides a flexible, realistic structure for aligning stakeholders with common objectives.

Box 3: Digital Public AI Infrastructure (DPAI) & Digital Public Goods (DPGs)

What is DPAI?

Digital Public AI Infrastructure (DPAI) refers to the integration of artificial intelligence into foundational digital systems that deliver public services—such as identity, payments, data platforms, registries, and service interfaces. Unlike isolated AI use cases in government, DPAI embeds AI directly into core infrastructure, enabling smarter, more adaptive, and inclusive public systems.

What is a Digital Public Good (DPG)?

DPGs are open-source software, datasets, AI models, or content that meet standards for accessibility, equity, privacy, and security, and are designed to be freely reused and adapted. When AI tools are built using open standards, are interoperable, and prioritize inclusion and accountability, they can qualify as AI-based DPGs—publicly available technologies designed for shared benefit.

Why link DPAI and DPGs?

Embedding AI into public infrastructure as a DPG ensures that governments retain control over core systems while avoiding over-dependence on private actors. This model allows for public scrutiny, local customization, and vendor-neutral innovation. For example, India’s Bhashini program—a multilingual AI platform developed as a DPG—supports voice translation across local dialects, increasing digital accessibility for non-English speakers.

What are the risks?

Without DPG principles, DPAI can replicate or even magnify inequality, exclusion, and surveillance. Closed-source biometric algorithms, for example, have been shown to embed racial bias and lack transparency in procurement. Governments risk black-box dependency, limited interoperability, and erosion of digital sovereignty if they do not govern AI tools as shared public assets.

Key Takeaways for Policymakers:

- **Design AI as DPGs:** Prioritize open, auditable, and rights-aligned AI systems that advance inclusion and equity.
- **Embed AI into DPI mindfully:** Build modular infrastructure that is adaptable, resilient, and citizen-centric.
- **Avoid lock-in:** DPG-aligned DPAI reduces dependency on proprietary vendors and promotes long-term sovereignty.
- **Invest collaboratively:** Partner in international DPG ecosystems to co-develop safe, adaptable AI tools for shared public benefit.
- **Govern ethically:** Enforce transparent procurement, independent auditing, and clear accountability frameworks.

2.2.4 MEASURE

Evaluating Outcomes and Reflecting on Goals

The Measure phase is where institutions assess whether their Digital Public Infrastructure (DPI) initiatives have achieved the public value they set out to deliver. It directly reflects on two fundamental questions defined at the outset of the framework:

- Were the goals clearly and meaningfully defined?
- To what extent did implementation deliver measurable, positive impact for citizens?

Unlike traditional performance reviews focused on technical deployment, this phase prioritizes societal outcomes. It examines whether DPI has led to tangible improvements in areas such as inclusion, service delivery, and socioeconomic opportunity. In doing so, it recognizes that a successful DPI is not merely functional—it is transformative.

The evaluation focuses on three outcome areas—Socioeconomic Advancement, Streamlined Public Service Delivery, and Digital Inclusion—which reflect the broader societal goals DPI is intended to support.

Each area is assessed using a three-level maturity model—Basic, Systematic, and Transformational—to understand the depth and breadth of adoption and impact. This structured approach allows for differentiated analysis across different country contexts and levels of development.

[A Cyclical Approach](#)

The Measure phase revisits the goals established in the Define phase, assessing whether the initiative has delivered on its intended public value. Crucially, this phase is not the end of the process, but part of the iterative Value by Design approach. Value-driven DPI is not achieved in a single cycle. Many successful national strategies have evolved through phased experimentation—starting with pilot projects focused on narrow service delivery areas. These pilots provided space to test assumptions, strengthen partnerships, and adapt technologies before scaling more widely.

Delivering value-centric impact is a long-term endeavor that often requires multiple iterations through the DPI lifecycle. Importantly, measurement should not rely solely on surface-level indicators such as user adoption or transaction volume. While these may provide early signals of momentum, they must be complemented by deeper outcome metrics that reflect citizen experience, equity, and systemic change.

When gaps are identified—whether in design, execution, or impact—they should trigger a return to the (Re)Define phase, where institutions can revisit their goals, update assumptions, and refine the design and delivery of DPI. This iterative cycle enables institutions to reassess objectives, update assumptions, and refine strategies in response to evolving needs and evidence.

This continuous learning loop is central to the Value by Design approach. It ensures that DPI remains responsive, accountable, and aligned with long-term public value.

3. Case Studies

Analyzing the Framework in Practice: Insights from Global Case Studies.

3.1 Selection Methodology

To validate and refine the Value by Design framework, a curated set of 18 case studies was selected to reflect the diverse landscape of Digital Public Infrastructure (DPI) implementation. Selection was guided by a combination of analytical criteria and strategic considerations. Cases were chosen to capture variation across geography, governance models, institutional maturity, and technological focus. This included initiatives led by governments, private actors, and hybrid collaborations, spanning a range of political, economic, and regulatory environments. These examples also cover different maturity levels of DPI ecosystems, with representation across the three core pillars—digital identity, payments, and data exchange. Each case was reviewed for its alignment with enabling conditions outlined in the framework, including political will, stakeholder coordination, institutional capacity, and private sector engagement. This approach enabled the framework to be stress-tested against real-world complexity, providing a foundation for extracting cross-cutting lessons and context-specific insights. The result is a more grounded and globally adaptable model for guiding DPI development.

Summaries of each case study can be found below, with our full analysis included in the appendix and our framework structure included [here](#).

3.2 Estonia

DEFINE: Estonia’s primary objective in developing the X-Road platform was to enhance the efficiency of public service delivery through seamless data exchange and interoperability. Rooted in a citizen-centric vision, the goal was to reduce administrative burden for both users and government employees by enabling secure, automated data sharing across institutions.

IDENTIFY: Estonia’s strategic commitment to digital transformation emerged shortly after its independence. Sustained political will, consistent leadership, and long-term national planning provided a stable foundation for DPI development. Digital infrastructure was treated as a strategic asset, enabling cross-sector coordination and unified service design. Significant investments in digital literacy, including national programs such as Tiger Leap and Look@World, raised internet penetration from 28.6% in 2000 to over 91% by 2016.

IMPLEMENT: Estonia adopted a public-private partnership model to develop X-Road, with the State Information Systems Department coordinating national ministries and private firms, most notably Cybernetica. The pilot, launched in 2000 and publicly opened in 2001, was supported by multi-agency funding and demonstrated early success through service-oriented use cases, reinforcing the program’s citizen-centric design and justifying national scale-up.

MEASURE: X-Road contributed to measurable improvements in government efficiency by significantly reducing data transfer and administrative processing times. However, its success was not measurable immediately, and was rather contingent upon widespread institutional integration and visible citizen benefits—particularly time savings and reduced bureaucratic complexity. Over time, the platform became a core enabler of Estonia’s digital government model.

3.3 Saudi Arabia

DEFINE: Saudi Arabia’s digital government strategy aimed to streamline the user experience by enabling seamless access to public services through a unified digital ecosystem. Anchored by a secure digital identity system, the initiative sought to eliminate bureaucratic barriers and improve accessibility for citizens, residents, and businesses.

IDENTIFY: Long-term political commitment, articulated through successive national strategies since 2006, provided a coherent roadmap for digital transformation. Enablers included a robust national identity platform (Nafath), strategic investments in infrastructure, strong cybersecurity governance, rising digital literacy (alongside a younger demographic skew), and an increasingly dynamic digital economy supported by public-private collaboration. The establishment of the Digital Government Authority (DGA) and initiatives like SDAIA’s AI training programs further institutionalized capacity across sectors.

IMPLEMENT: Saudi Arabia adopted a mixed implementation model, combining centralized leadership with private-sector delivery. The Ministry of Communications and Information Technology oversaw early planning through the Yesser program, while licensed firms such as Elm, Takamol, and Thiqah developed and managed major digital platforms. The launch of Absher in 2010 marked a turning point—consolidating services across ministries and demonstrating scalable, citizen-centric digital governance.

MEASURE: By the end of 2024, more than 28 million individuals—approximately 85% of the population—actively used digital identity credentials to access public services. The Absher platform alone processed over 600,000 daily transactions and reduced in-person visits to government offices by over 160 million. Remote court sessions, enabled by digital identity, now account for 95% of judicial hearings, cutting average litigation times by 86%. Broader benefits include improved business climate, greater service inclusion, and reduced environmental impact through digital efficiency.

3.4 Kenya

DEFINE: M-Pesa was launched as a private-sector initiative to address gaps in financial access by leveraging Kenya’s rapidly expanding mobile phone usage. Though driven by commercial incentives, the platform helped fill a critical development gap for unbanked, rural populations by enabling secure, low-cost digital money transfers.

IDENTIFY: At the time of launch, Kenya lacked foundational trust frameworks, governance capacity, and infrastructure to lead a government-managed DPI initiative. These gaps created space for the private sector to innovate, with Vodafone and Safaricom leading development alongside DFID support and flexible regulatory guidance from the Central Bank of Kenya.

IMPLEMENT: M-Pesa’s implementation followed an agile, market-driven model guided by iterative piloting, inclusive design, and low barriers to entry. The Central Bank’s ex post regulatory approach provided room for innovation while safeguarding users through audits, compliance checks, and oversight shared across financial and telecommunications authorities.

MEASURE: M-Pesa doubled its subscriber target in year one and drove financial access from 19% in 2006 to over 80% by 2019. These outcomes show how DPI led by private actors can still deliver developmental benefits when conditions align.

3.5 India-Singapore

DEFINE: The UPI–PayNow integration between India and Singapore was launched to reduce the high costs and complexity of traditional remittance systems (often exceeding 5% in fees) by enabling real-time, low-cost digital transfers. The initiative was designed to serve underserved groups such as migrant workers and small businesses, while also laying the foundation for broader regional integration through Project Nexus.

IDENTIFY: The initiative was underpinned by strong regulatory alignment and mutual trust between the Reserve Bank of India and the Monetary Authority of Singapore. Both governments provided high implementation capacity, formalized bilateral governance structures, and brought mature digital ecosystems and secure payment infrastructure to the collaboration. High smartphone adoption and prior experience with digital payments supported uptake, while privacy and cybersecurity safeguards were embedded from the outset.

IMPLEMENT: Led by central banking authorities, the UPI–PayNow system was built on scalable, cloud-based infrastructure that enabled real-time payments using only mobile numbers or virtual addresses. The phased rollout—from agreement to testing and launch within seven months—combined strong regulatory oversight with technical innovation, creating a user-friendly and interoperable model now informing cross-border payment integration across Asia.

MEASURE: The system halved average remittance fees and improved liquidity for migrant workers and SMEs, while simplifying access through familiar digital tools. By early 2024, UPI had expanded to seven

additional countries, and India emerged as a lead contributor to BIS’s Project Nexus, a multilateral initiative to interlink payment systems across Asia and beyond. The model demonstrates how purpose-driven, government-led DPI can scale inclusively across borders.



3.6 Brazil

DEFINE: PIX was developed by the Central Bank of Brazil to increase the efficiency, accessibility, and affordability of digital payments while reducing the country’s dependency on cash. Designed to overcome high transaction fees and delayed settlement times, it aimed to become the most user-friendly and widely adopted payment system in Brazil.

IDENTIFY: PIX was enabled by strong and legally autonomous institutional trust in the Central Bank, and by Brazil’s digitally fluent population and competitive fintech ecosystem. Despite limited legal protections for data and cybersecurity at launch, the Central Bank leveraged nearly two decades of financial reform experience, engaging both traditional banks and emerging fintechs in the system’s co-creation.

IMPLEMENT: PIX was implemented as a state-owned fintech with the Central Bank acting as both operator and regulator. Developed in collaboration with market actors and launched in 2020, the system uses open APIs, real-time settlement infrastructure, and inclusive access channels such as QR codes and mobile aliases. Its sustainability is ensured through a fee model for businesses and interoperability requirements for all regulated institutions, while built-in fraud monitoring and privacy safeguards support secure, round-the-clock usage.

MEASURE: The widespread adoption of PIX resulted in substantial economic gains, saving businesses and consumers approximately \$5.7 billion. Rapid growth in adoption numbers greatly reduced the dependence on cash-based transactions (from 79% in 2018 to 48% in 2024).

3.7 Mexico

DEFINE: Mexico’s adoption of X-Road in the state of Querétaro aimed to modernize administrative systems and increase efficiency at the local level. However, the initiative was driven more by the platform’s open-source flexibility than by a unified national strategy for interoperability or service transformation—resulting in a limited, state-level pilot with no clear path to national scale.

IDENTIFY: Despite relatively high internet coverage, Mexico faces persistent gaps in digital literacy, infrastructure quality, and institutional trust—only 17.4% of citizens report confidence in government. The pilot lacked federal support and was implemented without national architectural standards, performance benchmarks, or mechanisms for scaling across ministries or states. Technical expertise shortages and low inter-agency coordination further hindered effective execution.

IMPLEMENT: Led by Querétaro’s state institutions in collaboration with Estonian firm Roksnet, the platform was quickly deployed but only partially completed, hampered by limited stakeholder engagement and local technical capacity. The implementation lacked a national mandate, structured funding, or integration with broader digital identity or payment systems—undermining long-term viability and replication.

MEASURE: The pilot remains an isolated initiative with no published data on adoption, service efficiency, or citizen outcomes. Without evaluation frameworks, feedback loops, or impact assessments, Querétaro’s X-Road implementation has not demonstrated measurable improvements in public service delivery or inclusion. The absence of federal coordination and monitoring mechanisms limits its relevance as a scalable model for DPI in Mexico.

3.8 China

DEFINE: Yue Sheng Shi, launched by the Guangdong provincial government, was designed to streamline public service delivery through a “one-stop, one-click” platform that consolidates access to over 1,300 government services. Its objective was to digitize fragmented administrative systems, reduce in-person approvals, and offer equitable access across all levels of government.

IDENTIFY: Guangdong’s success with Yue Sheng Shi was enabled by early investments in mobile infrastructure, high smartphone adoption, and alignment with national strategies such as Digital China. The platform benefited from top-down administrative mandates, strong institutional capacity, and a governance model that emphasized security, interoperability, and cross-departmental integration—fueled by high levels of public trust in government-provided digital tools.

IMPLEMENT: Funded, developed, and operated entirely by the Guangdong government, Yue Sheng Shi employed a modular API-based architecture that enabled seamless onboarding of departments and service standardization across the province. Civil servant incentives, centralized data governance, and integration with China’s Unified Government Service Platform ensured rapid adoption, while public outreach campaigns drove uptake across both urban and rural populations.

MEASURE: As of 2023, the platform had reached over 50 million users and processed more than 2 billion service transactions, with over 95% of provincial services available digitally. Surveys report 90% user satisfaction, and a 2022 audit found an average 35% reduction in administrative processing times. With sustained public funding and national recognition, Yue Sheng Shi has become a benchmark for

scalable, citizen-centric DPI in China.

3.9 South Africa

DEFINE: M-Pesa was introduced in South Africa to promote financial inclusion through mobile-based money transfers. However, unlike in Kenya, South Africa's 75% banking coverage and mature financial infrastructure left little room for added value. The initiative lacked a localized objective, overestimated user demand, and failed to clearly define a structural gap it could fill.

IDENTIFY: Despite robust digital infrastructure and widespread mobile penetration, cultural norms, market saturation, and the absence of public-private coordination hindered adoption. Most consumers already had access to financial services and viewed traditional banks as more stable and trustworthy. Cultural usage of mobile phones remained centered around voice and entertainment, not finance.

IMPLEMENT: Led by Vodacom and Nedbank, M-Pesa's rollout was poorly targeted and lacked alignment with the needs of unbanked populations. The service offered limited local utility, had no meaningful agent network, and failed to integrate into daily financial life. Burdensome compliance and the absence of regulatory innovation further weakened its adaptability and reach.

MEASURE: By 2016, M-Pesa had only 76,000 active users—far below its 10 million target. It failed to reduce financial exclusion or shift consumer behavior toward mobile payments. With low engagement, limited relevance, and no institutional support, the platform was shut down, underscoring that DPI success depends on contextual fit, not just technical transfer.

4. Core Principles of Value by Design DPI

The following principles capture recurring themes observed across varied DPI trajectories and institutional landscapes.

These learnings are apparent across case studies, though, given the diversity of DPI applications, time frames, and country-specific attributes, no core principle is universally applicable. Instead, these principles should serve as guideposts for analyzing one's own DPI initiatives.

- 1. Build trust through various channels.** Trust in government, trust in data security, or trust in the private sector can each impact DPI development differently. Each facet of trust matters, but none are prerequisites for successful DPI. Rather, deficiencies in one aspect of trust may highlight a specific DPI development strategy.
 - ◆ Adoption of secure and transparent technical tools can help curb doubts regarding safety and privacy (e.g. **Estonia's** historical context provided strong incentives to build trust in their digital services);
 - ◆ Routine surveys can provide a clear picture of trust in DPI services (e.g. **Kenya's** Central Bank continuously running trust audits and user surveys), helping institutions adjust their course;
 - ◆ It is important to track online discourse and tackle disinformation around DPI, as abrupt changes in trust can impact adoption and usage of core services (e.g. **Brazil's** PIX reduced usage due to fake news about taxing).
- 2. Leapfrog DPI building blocks.** Traditional success stories followed a more structured approach - data exchange, then ID, then payments - but there are plenty of cases of countries successfully leapfrogging basic building blocks and going directly for payments.
 - ◆ Starting with data exchange and identification services can make it easier for next steps to be taken smoothly and quickly, but they often lack a more direct impact to citizens. **Estonia's X-Road and Saudi Arabia's National Information Center** illustrate this route.
 - ◆ Sometimes it is possible to leapfrog to payments, for example, without directly committing to ID or data. **Kenya and Brazil** are examples of cases in which the payment structure was deployed before they had the "previous" building blocks in place, and still had successes.
 - ◆ Leverage mobile and cloud-based strategies when infrastructure is lacking. While infrastructure maturity plays an important role in DPI readiness, even countries with limited resources can achieve rapid progress by leveraging mobile-first strategies (e.g. **Kenya**) or scalable cloud-based architectures provided the broader ecosystem is supportive.
- 3. Be the first-mover.** As with other digital services, DPI provides more value as more people use it, making it progressively harder to stray away from what was initially built. First-mover advantage is key, forcing nascent DPI initiatives to always be aware of what alternative services have to offer.

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- ◆ It is important to have a clear picture of alternative services already provided by other players, either public or private (e.g. **Brazil's** BCB evaluation of alternative payment services and **South Africa's** failure to compete with pre-existing services) to avoid redundancy;
 - ◆ Once core DPI services are built, lock-in effects make it difficult to switch to better alternatives, and markets might end up highly concentrated (e.g. Safaricom's dominance in **Kenya**).
 - ◆ Regulators can take action to reduce the ability of emerging initiatives to compete with core DPI services (e.g. **Brazil's** BCB blocking WhatsApp Pay before launching PIX).
- 4. Foster strong leadership for DPI's long term success.** Leadership need not be from the public sector, but adequate buy-in from institutions with the power to coordinate across partnerships will determine the ultimate outcomes. State-level initiatives should be aligned with national strategies to help secure support.
- ◆ **Saudi Arabia's** DPI success significantly benefited from sustained, high-level government commitment, evident through continuous strategic plans from 2006's e-Government Action Plan to the recent Smart Government Strategy
 - ◆ **China's** success was enabled by convergence between different levels of government. Yue Sheng Shi was aligned with national strategies (e.g. Digital China), backed by top-down administrative support and complemented by local digital governance capacity.
 - ◆ **Mexico's** initial DPI steps in Querétaro were embedded in Querétaro Digital 2022-2027 strategy (at the state level), but no apparent buy-in from the national government.
- 5. Use regulation to support scale.** Even though successful stories have been created without direct government involvement, government oversight is necessary to scale-up initiatives. Policies (e.g. data protection, competition, cybersecurity) provide legal stability for private and public agents, creating a more secure playing field for DPI initiatives to thrive.
- ◆ **Kenya** developed its DPI infrastructure with a private-led approach but, once Vodafone/Safaricom's pilot was a success, the Central Bank needed to enable key financial structures underlying the entire digital payments technology for it to scale.
 - ◆ Even though no data protection or cybersecurity laws were in place at the beginning of the project, **Brazil's** PIX and **Estonia's** X-Road benefited from the fact that the national government passed legislation in the following years.
 - ◆ **India and Singapore's** monetary authorities established clear governance frameworks and maintained close coordination throughout development and implementation, demonstrating how effective cross-border regulatory cooperation can enable financial innovation.
- 6. Attract and retain technical expertise to run a state-led DPI operation.** Effective DPI development relies on strong collaboration between government institutions and private-sector innovators. Successful cases of state-led DPI development (e.g. China, Brazil) have one thing in common: local

teams well-versed in the technical requirements of building DPI. When local technical expertise is absent, governments can struggle to scale-up pilots developed by the private sector (e.g. Mexico).

- ◆ Mixing state-leadership with a startup mindset, **Brazil's** PIX leveraged the technical knowledge present in its Central Bank to not only design its systems, but also operate them.
- ◆ **Querétaro (Mexico)** struggled with maintaining and scaling the infrastructure built by Roksnet in the state, partly due to a lack of local technical expertise and knowledge on the technologies used.

7. Embed Interoperability from the outset as a core design principle rather than retrofit it later. This ensures that digital public infrastructure can scale effectively, support cross-sector integration, and avoid fragmentation beyond initial pilot deployments.

- ◆ Interoperability was a stated goal of X-Road from the outset, as **Estonia** saw interoperability and as a necessary component to operating efficiently while avoiding an over reliance on large vendors.
- ◆ **Saudi Arabia's** digital government journey has emphasized interoperability since the launch of its first e-Government Action Plan in 2006, which established the vision for cross-ministerial integration. Over time, this vision was institutionalized through platforms like Nafath and Absher, and reinforced by the creation of the Digital Government Authority (DGA), which now sets and enforces interoperability standards across public agencies to ensure cohesive and scalable digital service delivery.
- ◆ The **India–Singapore** UPI–PayNow corridor was built on a modular, API-based design from the start, enabling seamless transfers and paving the way for broader regional integration through Project Nexus.

8. Welcome international collaboration along all maturity levels. While some countries have developed their own infrastructure first and then scaled it up to include other nations (e.g. India and Singapore), others have found international collaboration to be essential from the get-go (e.g. Kenya, Mexico, South Africa). When international collaboration happens at the start, however, it is fundamental to have clarity on what the local context is.

- ◆ Importing successful solutions does not always result in local success. In their efforts to replicate X-Road and M-PESA successes, **Mexico** and **South Africa** faced local challenges that ultimately resulted in project failure.
- ◆ That is why piloting international collaboration is paramount. **Kenya's** MPESA was first piloted with support from Vodafone and the UK Government, and only expanded once positive and consistent results were obtained.
- ◆ Both **India and Singapore** had stable DPI infrastructure when they reached for international collaboration, resulting in a more robust solution.

9. Ensure DPI is financially sustainable. As with any other infrastructure project, DPI is heavily dependent on budgeting, both for financing and maintaining it afterwards. Budget constraints can be wrestled with during different phases of DPI development.

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- ◆ Financing through collaboration. Financial constraints at the beginning of DPI development can be addressed through private-sector involvement and/or international collaboration (e.g. **Kenya, South Africa**).
 - ◆ Financial sustainability should be seen as one of the main components of DPI, and built into the design of the system. The system could impose fees for some of the agents using their services, making it possible to maintain the system working without depending on national budgeting (e.g. **Brazi**).

10. Deploy DPI in phases. Before committing with a specific system design, test it. A phased approach allows for players to adjust their course and deliver value without incurring major risks. Once the main DPI systems are in place, institutions should divert efforts and attention towards maintaining them, ensuring services are reliable and trusted.

- ◆ **India and Singapore's** UPI-PayNow phased implementation—from the July 2022 agreement through late-2022 testing to the February 2023 launch—ensured thorough validation ahead of public deployment.
- ◆ **Mexico's** X-Road pilot failed due to a lack of technical support, but at a smaller scale, which still leaves an opportunity open for future projects. **South Africa's**, on the other hand, tried to scale too quickly and confidently, and would benefit from a slower approach to DPI.
- ◆ **Saudi Arabia's** phased, iterative approach allowed the digital platforms to evolve continuously, progressively enhancing service quality, expanding coverage, and integrating new functionalities, thus demonstrating scalability and adaptability in digital governance.

11. Be ready for the next frontier of DPI. As institutions and citizens experience the value of digital infrastructure, new initiatives are being built to expand the benefits DPI can bring, both locally and globally. Players should be ready to adapt what they have already built to a new set of services.

- ◆ Successful DPI stories at the national level open up space for regional expansion, with countries either taking their own solutions to other states (e.g. **Estonia, Brazil**) or using their existing infrastructure to develop new projects altogether (e.g. **Singapore and India**)
- ◆ DPI is built to allow for other services to be seamlessly included in a country's stack. These include open-source software, open data, open AI models (DPAI), open standards, and open content, which are often referred to as Digital Public Goods (DPG).

5. Recommendations & Next Steps

Moving forward, the VbD Framework should be used in action to inform future DPI initiatives, educate stakeholders, and provide a jumping off point for WEF’s leadership on DPI.

5.1 Unlocking the Value of the VbD Framework

The goal of creating the Value by Design Framework is to develop a shared understanding of how DPI can best generate value for citizens globally. This report posits that DPI is not in itself valuable, but that **through DPI, practitioners can generate meaningful value for citizens** and in doing so, increasing disparate societal factors from digital literacy to trust in the public sector and government efficiency.

Society can fully unlock the transformative potential of Digital Public Infrastructure only by recognizing its true value as a conduit for efficient, citizen-centered service delivery. By examining shared opportunities and challenges in existing DPI initiatives, this report presents a guidebook for how to conceptualize, initiate, and realize tangible value for DPI applications. The Value by Design Framework acts as scaffolding, offering a set of considerations that actors across the public and private sector can use to enhance their own initiatives.

Moving forward, this Framework requires promotion, use, and iterative adjustments to maximize its own value in the growing global DPI discussion. Future work should seek to:

- Socialize the Framework to key stakeholders and major champions of DPI.
- Develop an accompanying DPI Maturity Model.
- Refine the Framework via a series of “VbD Framework in Action” reports.
- Compile a centralized knowledge-base of global DPI initiatives.

As the global conversation around DPI evolves, the World Economic Forum is uniquely positioned as both a convener and catalyst for DPI efforts rooted in public value. In doing so, the Forum can take a leading role in shaping inclusive, future-proofed DPI worldwide.

5.2 Next Steps

[Socialize the Framework to Key Stakeholders and Major Champions of DPI](#)

While our framework has benefitted from expert feedback across the public and private sectors, the Forum could further enhance its findings through the convening of stakeholder working groups. This feedback will strengthen the framework and establish the Forum as a critical thought leader in DPI development.

-
- Organize roundtables with policymakers, technologists, civil society actors, and private sector leaders to stress-test the framework across diverse contexts and viewpoints.
 - Use these convenings to gather case studies, generate shared language, and refine framework categories (e.g., enablers, outcomes, maturity levels).

[Develop an Accompanying DPI Maturity Model](#)

The DPI community would benefit from a standardized maturity model to classify countries according to their progress across key DPI components. Such a model could provide a comparative lens through which governments, donors, and implementers could assess DPI evolution and identify actionable gaps.

- Use VbD Framework to develop a model to systematically assess DPI evolution.
- Tailor policy and implementation recommendations for countries at different stages of DPI development based on DPI Maturity Model to support more context-sensitive planning and resource allocation.

[Refine the Framework via “VbD Framework in Action” Reports.](#)

This framework would benefit from practical applications, which the Forum could elicit through their global offices and connections. These pilot country partnerships would serve as living labs, offering real world applications and learnings from current DPI initiatives.

- Select countries at varying stages of DPI maturity to serve as “living labs” for the framework, highlighting operational successes and challenges in DPI design, implementation, and measurement.
- Develop follow-up publications that demonstrate the framework’s practical application, modeled after the C4IR’s *Unpacking AI Procurement in a Box* case study in Brazil.

[Compile a centralized knowledge-base of global DPI initiatives](#)

DPI initiatives could benefit from a centralized repository, showcasing the diversity and ingenuity of advancements in the DPI sector. By creating and hosting such a repository, the Forum could establish itself as an indispensable actor in DPI development.

- Launch a centralized, WEF-hosted knowledge platform with searchable case studies, policy briefs, and toolkits linked to DPI efforts around the world.
- Maintain a standardized data repository on DPI development across countries, to ensure that maturity can be evaluated uniformly.

Appendix

A.1 Authors

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A.2 Case Studies

A.2.1 Selection Methodology

To validate and refine the Value by Design framework, a curated set of 18 case studies was selected to reflect the diverse landscape of Digital Public Infrastructure (DPI) implementation. Selection was guided by a combination of analytical criteria and strategic considerations. Cases were chosen to capture variation across geography, governance models, institutional maturity, and technological focus. This included initiatives led by governments, private actors, and hybrid collaborations, spanning a range of political, economic, and regulatory environments. These examples also cover different maturity levels of DPI ecosystems, with representation across the three core pillars—digital identity, payments, and data exchange. Each case was reviewed for its alignment with enabling conditions outlined in the framework, including political will, stakeholder coordination, institutional capacity, and private sector engagement. This approach enabled the framework to be stress-tested against real-world complexity, providing a foundation for extracting cross-cutting lessons and context-specific insights. The result is a more grounded and globally adaptable model for guiding DPI development.

Summaries of each case study can be found below, with our full analysis included in the appendix and our framework structure included [here](#).

A.2.2 Estonia

BACKGROUND

Over the past 25 years, Estonia has developed one of the most advanced digital public infrastructures globally, serving as a model and catalyst for DPI development worldwide. While Estonia’s digital ecosystem includes systems for digital ID, payments, and residency, the backbone of this infrastructure is X-Road (formerly known as X-tee)—a platform enabling secure data exchange between government agencies, citizens, and organizations. As one of the earliest and most mature examples of national data exchange architecture, X-Road offers a valuable case study through which to apply and assess the Value by Design framework.

Given the long arc of Estonia’s digital journey, it is most appropriate to examine X-Road not as a singular deployment but as a series of iterative developments across the DPI lifecycle. Each phase featured distinct goals, enabling conditions, and implementation approaches that together enabled Estonia to refine, expand, and strengthen its infrastructure over time. This case study begins with the program’s foundational phase.

DEFINE

[Efficiency](#)

The central objective of X-Road was to streamline public service delivery for both citizens and civil servants. In the late 1990s, Estonia’s public administration operated siloed databases with no standardized mechanisms for data sharing. The absence of centralized governance or interoperable systems made cross-agency coordination slow and inefficient ([Cybernetica](#)). In response, the 1998 *Principles of Estonian Information Policy* set forth a vision for “high-quality...equal and affordable access to communication facilities,” regardless of geographic location ([Estonia’s Informatics Council, 1998](#)). X-Road emerged as a key enabler of this vision.

[Interoperability](#)

From its inception, interoperability was a core design principle of X-Road. In a post-Soviet context marked by limited financial resources, Estonia sought to build a scalable system that would avoid reliance on large external vendors ([Principles of Estonian Information Policy, 1994, Estonia’s Informatics Council](#)). This “no legacy” principle—articulated in Estonia’s 1994 informatics strategy—prompted the government to pursue a distributed data exchange architecture that empowered agencies to manage their own systems while participating in a shared ecosystem ([Great Policy Successes](#), 150). Although not codified in law, this emphasis on interoperability and decentralization became foundational to Estonia’s DPI philosophy.

[Establishing a Digital National Identity](#)

A more symbolic but equally important goal of X-Road was to reinforce Estonia’s identity as an independent, forward-looking digital state. The initiative was explicitly framed as a departure from the centralized and opaque systems of the Soviet era, aligning Estonia more closely with Western Europe and the Nordic digital model ([Great Policy Successes](#), 146). As noted by Cybernetica’s Arne Ansper, early proponents viewed the expansion of ICT capabilities as a means of generating “positive attention” and strengthening Estonia’s global reputation (Anspers, [E-State from a Data Security Perspective](#), 5). In this sense, the success of X-Road was inseparable from the broader ambition of establishing Estonia’s digital sovereignty and leadership.

[Pilot Specific Goal](#)

The pilot phase of X-Road had a focused and measurable objective: to demonstrate the technical feasibility of interoperable data exchange across government systems. The successful public launch of a

functioning prototype in 2000 served as a proof of concept, validating the architecture and paving the way for full-scale implementation.

IDENTIFY

Several core enablers contributed to the development and successful deployment of X-Road in Estonia, notably digital trust, governance capacity, infrastructure readiness, and digital literacy. While comprehensive metrics for the early 2000s are limited, available data and qualitative evidence provide insight into the conditions that made Estonia’s digital transformation possible.

[Trust](#)

Trust served as a foundational enabler of Estonia’s digital journey, underpinned by a strong emphasis on security, transparency, and citizen control over data.

To build confidence in service providers, Estonia implemented data protection laws, ensured citizens could access their data logs via the eesti.ee portal, and mandated strict authentication and encryption protocols for all X-Road transactions ([E-Estonia, 2019](#)). The use of independent audits and the enforcement of uniform cybersecurity standards for participating entities further reinforced systemic integrity ([Data protection laws in Estonia, 2025](#)).

For trust in the DPI system itself, Estonia adopted a decentralized architecture to prevent data monopolization, integrated [KSI Blockchain](#) for tamper-proof security, and continuously monitored cyber threats through the State Information Systems Authority (RIA). The [Data Embassy](#) in Luxembourg provided a secure backup to safeguard digital services from cyberattacks or crises.

Historical and political context also played an enabling role. Estonia’s post-Soviet drive to align with Western Europe provided strong political will for digital modernization. Its relatively small and urbanized population further facilitated citizen-scale adoption and digital literacy programming.

[Government](#)

Estonia’s approach to digital governance combined legal innovation with agile institutional coordination. Key legislative milestones included the Digital Signatures Act (2000), which provided a legal foundation for e-signatures, and the Public Information Act (1996), which formalized the transparency of digital records ([Digital Signatures Act, 2000](#); [Public Information Act, 1996](#)). Alongside formal legislation, Estonia applied a set of design principles that shaped system development—such as the “no legacy” principle favoring modern technologies and the “once-only” principle, which stipulated that citizens should not have to repeatedly submit the same data to different government agencies ([Great Policy Successes](#), 154). These principles provided clearly defined guidelines for the X-Road team without increasing bureaucratic burden.

Crucially, Estonia fostered close cooperation between policymakers, technologists, and academic institutions. Informal networks and shared vision across these communities played a pivotal role in driving innovation. Academic institutions, in particular, offered both technical expertise and international

connections that helped embed Estonia’s digital reforms in global best practices ([Great Policy Successes, 149](#)).

[Infrastructure](#)

Following independence in the early 1990s, Estonia prioritized investment in nationwide connectivity. By 2002, the government had introduced free public Wi-Fi networks and ensured broadband access in all schools. Educators received ICT training as part of the Tiger Leap initiative, and government reports indicated growing digital penetration across sectors.

Estonia ranked 16th in the UN E-Government Development Index (EGDI) in 2003, which measures online service delivery, telecommunications infrastructure, and human capital. The country also held the 31st position in the ITU ICT Development Index, with one of the world’s highest mobile subscription rates—65% by 2002—highlighting the readiness of its communication infrastructure to support a data-driven government ([International Telecommunication Union, 2002](#)).

[Digital literacy](#)

Estonia viewed digital skills as an essential counterpart to infrastructure investment. By 2000, the Tiger Leap program had equipped schools with computers and internet access, while the Look@World initiative trained 100,000 adults—roughly 10% of the population—in basic digital skills ([Konrad-Adenauer-Stiftung, 2021](#)). This effort also increased the number of public internet access points from 200 in 2001 to 700 in 2004, expanding reach to underserved communities.

Metrics from this period reflect substantial progress. In 2004, 56% of the population regularly used computers, and internet penetration had already reached 28.6% by 2000—well above the global average of 15.6% at the time. Estonia’s **Human Capital Index** stood at 0.95, significantly higher than the global average of 0.70. By 2016, internet usage had climbed to over 91%, marking a successful trajectory from digital literacy training to widespread adoption ([Centre for Public Impact, 2019](#)).

IMPLEMENT

[Partnership Model](#)

Estonia’s development of X-Road was driven by a public–private collaboration between the State Information Systems Department and Cybernetica, a domestic IT firm with roots in the Estonian Academy of Sciences ([Cybernetica](#)). Privatized in 1997, Cybernetica brought both technical expertise and institutional continuity, and was contracted to build both the pilot and the core software infrastructure for X-Road.

Project financing was secured through multiple public bodies, including the Ministry of Transport and Communications, the Ministry of the Interior, and the Government Office. Overall program coordination was managed by the State Information Systems Department (RISO) under the Ministry of Economic Affairs ([X-Road: X-Road History](#)). The initiative benefited from strong cross-sector leadership, particularly

through the role of Linnar Viik, an entrepreneur who served as a bridge between government, academia, and the private sector ([X-Road: X-Road History](#)).

The initial pilot, launched in 2000, connected three government databases and served as a demonstration of the feasibility of secure, interoperable data exchange. Following its success, the program formally expanded in 2001. A consortium of private-sector partners—led by AS Assert—was awarded an initial contract of 5.14 million kroons, with planned investments totaling 30 million kroons over the first three years of implementation ([Postimees, 2001](#)). Cybernetica remained responsible for the system’s architecture, while additional firms—including AS Andmevara (now Novian), Reaalsüsteemide AS, and AS Datel—contributed by testing service queries and integrating specific datasets. Estonia’s commercial banks were enlisted to provide user authentication, highlighting the ecosystem approach taken to building and scaling X-Road ([X-Road: X-Road History](#)).

The platform officially launched on **17 December 2001**. Initial integrations included the land registry, car registry, population registry, and immigration information systems. Notably, the project’s guiding principle centered on **citizen-facing services**, not simply inter-database connectivity ([Postimees, 2001](#)). As **Uuno Vallner**, a leader on the X-Road project, stated in an interview with *Postimees* in 2001 :

“Citizens are actually not interested in databases, but in services

*I want to get a birth certificate for my child, I want to be Latvian in the future,
I need some evidence to conclude a gift agreement, etc.”*

This early articulation of service design—focused on real-life user needs—was instrumental in ensuring that X-Road delivered meaningful value to citizens, setting a precedent for future iterations.

MEASURE

[Pilot Program](#)

The pilot phase of X-Road achieved its foundational objective: demonstrating the technical feasibility and operational viability of a decentralized data exchange system. By 2000, a working prototype had been successfully deployed, laying the groundwork for broader implementation across government systems.

[Efficiency](#)

Efficiency metrics in the initial years are difficult to identify, with much of the impact analysis beginning in 2003. However, available figures provide insight into the platform’s initial reach and user engagement. By 2003, X-Road had integrated 18 databases and enabled services across approximately 10 government institutions (World Bank, 2014). At that time, around 30,000 citizens—roughly 2% of Estonia’s population—had accessed services via the platform. While modest, this adoption rate reflected broader trends in digital uptake, as a 2002 survey showed that 58% of adults aged 15–74 had limited or no experience using the internet ([Digital Divide in Estonia, 2002](#)).

Analysis completed by the World Bank in 2014 confirms this finding, indicating that uptake from Estonian’s population was linear and relatively slow at first, but that queries increased exponentially after 50 databases were included on X-Road, reaching a critical mass after which services can readily be provided.

Time saved provides a proxy for efficiency, and directly reflects the initial goals of the X-Road software to reduce time for citizens and public workers to access government services. While there is no direct measure on time saved, the World Bank estimates that each query on X-Road could save between 5-60 minutes, corresponding to hundreds of years of time saved by the Estonian population. Estonian survey respondents in 2002 support the importance of time saving, with loss of time ranking as the “most unpleasant” when attending to tasks. However, digital literacy gaps remained a barrier to realizing these efficiencies broadly. While early adopters valued the reduction in administrative burden, digitally inexperienced users often found the learning curve steep and perceived online services as time-consuming rather than time-saving ([Digital Divide in Estonia](#), 2002, 59).

Taken together, early measurement outcomes reinforced the importance of expanding database integration and investing in citizen-facing education campaigns—both to drive usage and to deliver on X-Road’s promise of inclusive, accessible digital services. This was echoed in a 2002 report by PRAXIS and the Open@World initiative, which emphasized the need to raise awareness of available digital services and improve the usability of e-government platforms ([Digital Divide in Estonia](#), 2002).

[Interoperability](#)

X-Road achieved one of its core technical goals by delivering a scalable, secure, and decentralized interoperability framework at the national level. Its design—based on modular integration and distributed architecture—enabled seamless data exchange across government agencies, without centralizing control. This success validated the early design principle that interoperability was not just a technical requirement, but a foundational enabler of digital public infrastructure.

[Digital National Identity](#)

The successful rollout of X-Road significantly contributed to Estonia’s broader ambition of establishing a distinct digital national identity. In addition to enabling efficient service delivery, the platform became a symbol of Estonia’s departure from its Soviet legacy and its alignment with modern, digitally empowered states in Western and Northern Europe. The country’s rapidly growing tech sector, most notably the global success of Skype, further amplified Estonia’s image as a leader in digital innovation, strengthening both national pride and international recognition.

A.2.3 Saudi Arabia

BACKGROUND

In 2005, the majority of government services in Saudi Arabia were still paper-based, with public agencies operating in silos. This fragmented model contributed to inefficiencies, inconsistent service delivery, and limited accessibility for citizens and residents. At the time, Saudi Arabia ranked 80th out of 193 countries in the UN e-Government Development Index (UNEGDI), reflecting its nascent stage of digital governance.

To address these systemic challenges, the government launched the e-Government First Action Plan in 2006, marking a foundational shift toward a more strategic and coordinated approach to digital transformation. This initiative introduced a forward-looking vision centered on providing high-quality, user-centric digital services, while also strengthening inter-agency coordination.

A cornerstone of this strategy was the development of a unified digital identity system, which enabled secure authentication and served as a critical enabler for service integration. Over time, this infrastructure has evolved to support an expanding suite of digital services and transactions. Today, digital identity remains central to Saudi Arabia's ongoing DPI efforts, underpinning improvements in service delivery, operational efficiency, and citizen engagement.

DEFINE

Saudi Arabia's digital government strategy was designed to streamline the citizen experience and ensure equitable, consistent, and seamless access to public services. At the time of its launch, users faced a fragmented landscape of government touchpoints—characterized by complex procedures, limited availability, and the need for in-person interactions across multiple agencies.

In response, the First Action Plan prioritized the creation of a cohesive and user-friendly digital ecosystem—one capable of delivering integrated services across all sectors of government. Central to this effort was the introduction of a secure and interoperable digital identity platform, enabling individuals to authenticate their identity and access a broad range of services through a single, unified interface ([First Digital Strategy and Action Plan](#), 2006). This strategic focus on identity not only addressed pain points in the existing system, but also laid the groundwork for the scalability and extensibility of future digital services.

IDENTIFY

The development of digital public infrastructure (DPI) in Saudi Arabia has been shaped by a convergence of enabling factors, including advancements in infrastructure, sustained government leadership, growing digital literacy, increasing trust in digital systems, and the maturation of digital markets.

[Trust](#)

At the outset of Saudi Arabia's digital transformation in the mid-2000s, trust enablers were limited. However, the Kingdom has since made significant institutional progress in strengthening cybersecurity

and data protection frameworks. The establishment of the National Cybersecurity Authority (NCA) in 2017 marked a pivotal step in securing public trust, with a mandate to safeguard national security, critical infrastructure, and digital government services. The National Cybersecurity Framework outlines core controls—including governance, asset management, risk mitigation, and third-party security—aligned with international best practices to promote a consistent approach to managing cybersecurity risks across sectors.

In parallel, Saudi Arabia introduced the Personal Data Protection Law (PDPL), providing a structured legal framework to protect individual privacy while enabling responsible data use in support of the Kingdom’s digital economy. The PDPL grants citizens explicit rights over their personal data and sets requirements for consent-based processing, secure storage, and regulated cross-border transfers. These developments have positioned trust as a foundational pillar of Saudi Arabia’s digital transformation journey.

[Government](#)

From inception, Saudi Arabia’s digital ID system and broader DPI strategy have benefited from high-level political support and coordinated governance. The country has implemented a phased strategic roadmap for digital transformation, beginning with the 2006–2010 e-Government Action Plan, followed by subsequent strategies focused on service quality, digital workforce development, and citizen-centric service delivery. The Smart Government Strategy (2020), closely aligned with Vision 2030, reaffirmed this commitment by emphasizing inclusivity, efficiency, and seamless user experiences.

A cornerstone of these efforts has been capacity building and knowledge transfer, particularly through collaboration with global technology partners. These efforts have significantly elevated national technical capacity, especially in the cybersecurity domain ([PwC, 2024](#)). Saudi Arabia’s performance in the UN E-Government Human Capital Index has improved markedly—from just below the global average in 2003 to well above it in 2024.

Robust public–private partnerships (PPPs) have also underpinned Saudi Arabia’s DPI development. The Digital Government Authority (DGA) has played a key enabling role, issuing licenses to domestic technology firms, including Elm for Information Security, Takamol Business Services, and Thiqah, to develop and operate digital government platforms and products.

[Markets](#)

In the early 2000s, Saudi Arabia’s digital economy was still nascent, with most enterprises operating offline and limited support for digital entrepreneurship. Recognizing this gap, the government proactively cultivated a market ecosystem to support DPI alongside public sector reforms.

To enhance the competitiveness of its digital infrastructure, Saudi Arabia introduced the [Telecommunications and Information Technology Act](#). The Act aims to develop an efficient information technology sector that encourages digital transformation, technical innovation, technology localization, and raising the competitiveness of telecommunications companies. A key focus of the law is to empower

startups and SMEs by creating a supportive regulatory environment that encourages their active participation in the digital economy.

[Infrastructure](#)

The evolution of Saudi Arabia's ICT infrastructure has been both deliberate and substantial. Internet access was initially introduced in 1993 for academic use and expanded commercially by 1999. By 2001, internet users had reached 1 million, equivalent to approximately 5.8% of the population. Since then, infrastructure investments have accelerated significantly ([Potomac Institute for Policy Studies, 2017](#)).

Over the past six years, the Kingdom has invested more than \$24.8 billion to upgrade its digital infrastructure. As of late 2023, internet penetration stood at nearly 99%, while 5G coverage reached 77% nationwide, including 94% in Riyadh, placing the capital among the top-ranked global cities for connectivity. These advances have dramatically enhanced the scalability and reach of DPI platforms.

[Digital literacy](#)

A young, digitally fluent population has been instrumental in driving the success of Saudi Arabia's DPI initiatives. High rates of smartphone usage, near-universal internet access, and targeted investments in digital skills development have fostered widespread digital adoption.

The Saudi Data and AI Authority (SDAIA) has led national efforts to build a future-ready workforce. Through its educational academy, SDAIA has trained over 590,000 young people in AI, supported by global partnerships—including initiatives like Elevate with Google Cloud to promote women's participation in tech. These programs support Vision 2030 goals and contribute to long-term DPI sustainability.

High levels of digital engagement are already evident. The Kingdom's national authentication platform, Nafath, is linked to 485 service providers and serves 23 million users, covering over 70% of the population. This reflects both the accessibility and effectiveness of DPI when anchored in strong digital literacy foundations.

IMPLEMENT

In 2005, the planning e-Government program (Yesser), a platform to facilitate access to government information and government services, was led by the Ministry of Communications and Information Technology, and had representatives from other government agencies in its board to foster interoperability. The operational development and maintenance of digital platforms were carried out through licensed private and semi-private firms, under the regulatory oversight of the Digital Government Authority (DGA). The DGA issued licenses to three key national players—Elm Company, Takamol Business Solutions, and Thiqah—tasking them with enhancing and operating 15 sector-specific platforms. These platforms span diverse areas such as logistics, labor market services, legal documentation, and healthcare, reflecting Saudi Arabia's commitment to embedding digital access across government functions ([Argaam, 2022](#)).

A significant milestone in this process was the 2010 launch of Absher, a flagship digital platform developed by the Ministry of Interior. Absher consolidated multiple public services—ranging from passport renewals and visa applications to traffic violation inquiries and civil affairs—into a single digital access point. Designed for citizens, residents, and visitors, Absher exemplifies Saudi Arabia’s DPI principle of “anytime, anywhere” access, and has since evolved into one of the country’s most widely used public service platforms.

The implementation approach prioritized iterative development, scalability, and centralized authentication via digital identity systems, allowing for seamless service expansion and consistent user experiences. Through this model, Saudi Arabia laid the groundwork for a DPI ecosystem characterized by strong regulatory coordination, secure data governance, and citizen-facing accessibility.

MEASURE

[Access](#)

As of December 2024, over 28 million digital identities were actively in use, representing approximately 85% of Saudi Arabia’s population. This widespread adoption underscores the success of the national digital identity initiative in enabling secure and seamless access to digital government services. The flagship platform Absher played a central role in this transformation, processing an average of 605,000 digital transactions per day. By integrating services such as driver’s license renewals, passport issuance, and civil affairs, Absher has contributed to a reduction of over 160 million in-person visits to government offices, substantially enhancing service accessibility and operational efficiency.

Beyond administrative efficiency, the DPI ecosystem has generated broader socioeconomic dividends. Enhanced ease of doing business has improved the Kingdom’s attractiveness for investment and entrepreneurship. Reduced reliance on physical service delivery has contributed to lower CO₂ emissions through fewer commutes and reduced resource consumption.

A.2.4 Kenya

BACKGROUND

In 2007, Kenya launched M-Pesa, a mobile payments platform developed jointly by telecom provider Safaricom and the Commercial Bank of Africa. Initially focused on person-to-person digital cash transfers, M-Pesa rapidly expanded its use cases to support transactions between individuals, businesses, and government entities. The platform emerged as a transformative response to widespread financial exclusion, enabling millions of Kenyans to participate in the formal economy via mobile phones (Ndung’u, 2019).

This case study applies the Value by Design framework to examine the enabling conditions, implementation strategy, and measurable outcomes of Kenya’s DPI journey through M-Pesa. It explores the strategic choices that contributed to its success and identifies lessons relevant for governments seeking to leverage DPI to promote financial inclusion and economic development.

DEFINE

[Enabling Financial Inclusion through Digital Infrastructure](#)

While M-Pesa was led by the private sector, its development was grounded in a clear public value proposition: extending financial access to underserved populations. In the early 2000s, structural limitations in Kenya’s banking system left much of the population excluded. Only 19% of Kenyans held a bank account in 2006, and nearly 40% were entirely outside the financial system (Money, Real Quick, 2012). The traditional banking model was ill-suited to reach rural populations due to cost constraints and infrastructure limitations.

At the same time, mobile phone adoption was growing exponentially, rising from just 2% in 2000 to 35% in 2006. This created a powerful channel through which digital services could be delivered. Safaricom recognized an opportunity to bridge this divide by enabling basic financial services through mobile technology. M-Pesa’s goal was to leverage this emerging connectivity to promote inclusive economic development, while also positioning itself as a first mover in a largely untapped mobile payments market.

Though initially targeting 300,000–350,000 users in its first year, M-Pesa’s leadership set a more ambitious benchmark of reaching 1 million subscribers, reflecting a bold commitment to rapid scale. This approach highlights the difference in goal-setting between public sector-led DPI and private-sector innovation, where market-driven incentives and agility often drive faster execution—even when strategic alignment with broader public value emerges more implicitly.

IDENTIFY

A range of contextual factors shaped the trajectory of M-Pesa’s development and success, including early-stage limitations in digital governance, infrastructure, and institutional trust. While traditional DPI enablers were largely underdeveloped at the time, these very constraints created space for private-sector innovation to take root.

[Trust](#)

Digital trust provisions in Kenya prior to the launch of M-Pesa were scarce, though the Kenyan government had indicated a need for more concrete measures around information and communications technology (ICT) (National ICT Policy, 2006). Such acknowledgements include a need to establish laws to enhance cybersecurity and protect privacy and intellectual property, a need to invest in digital infrastructure to support rural areas of the country, a need to increase digital literacy, and a need to

establish a strong e-government for the purpose of providing “services in an efficient and effective way” (National ICT Policy, 2006, 6).

These proclamations, delineated in Kenya’s National ICT Policy, are not binding, but they underscore the degree to which the Kenyan government was at least conceptualizing the need for a strengthened ICT sector, and the role that the government must play in establishing this. Yet, with little trust frameworks established (and given a government crisis which began shortly after the launch of M-Pesa), the government was not well-situated to undertake a project like M-Pesa, leaving the private sector as a more suitable option.

Government

While public-sector governance structures were not the primary drivers of M-Pesa’s development, they played a contextual role in catalyzing its uptake. The instability following Kenya’s 2007 elections temporarily disrupted banking operations, creating a window for digital payments to meet urgent needs. M-Pesa’s ability to facilitate transfers during periods of civil unrest further reinforced its utility and value proposition.

Importantly, governance in the M-Pesa case was shaped more by corporate leadership than by state actors. The platform was conceptualized by Nick Hughes of Vodafone and funded in part by the UK’s Department for International Development (DFID) (Money, Real Quick, 13). Safaricom’s leadership, particularly CEO Michael Joseph, championed the project internally, ensuring strong executive backing during its pilot and scale-up phases. The governance structure within Vodafone and Safaricom provided the clarity, continuity, and execution capacity that public institutions at the time lacked.

Markets

Kenya’s market environment was limited in terms of digital entrepreneurship and innovation ecosystems. However, these constraints did not inhibit M-Pesa’s growth, but rather amplified it. Safaricom’s commanding 65% market share in the telecommunications sector provided a ready-made user base and powerful distribution channel (Money, Real Quick, 24). The absence of competing platforms allowed M-Pesa to scale quickly, achieving first-mover advantage and embedding itself into the daily lives of millions.

While the broader innovation ecosystem remained nascent, M-Pesa benefited from international technical expertise and funding, with early development support based in the UK. This global-local hybrid model enabled rapid prototyping and deployment in a market where local capacity was still emerging.

Infrastructure

At the time of M-Pesa’s debut, Kenya’s digital infrastructure was underdeveloped. Fewer than 5% of the population used the internet in 2007, and the country ranked 116th globally in the ITU’s ICT

Development Index ([ITU](#)). Performance was similarly limited on the UN's E-Government Development Index, with particular weaknesses in telecommunication capacity.

However, mobile phone penetration was rising sharply, reaching 35% by 2006 (Money, Real Quick, 13). This created a foundational enabler: a device already embedded in daily life that could be repurposed for financial access. M-Pesa strategically capitalized on this shift, leveraging SMS technology to bypass more infrastructure-intensive models and extend reach even in low-connectivity areas.

[Digital Literacy](#)

Digital literacy levels were low, particularly outside urban centers. To address this, M-Pesa was deliberately designed around simple, intuitive workflows using SMS—a technology already familiar to much of the population. Initial uptake skewed toward young, urban men, who used the platform to send remittances to rural family members.

By removing the need for internet access or banking experience, M-Pesa lowered the threshold for participation in the formal economy, gradually building digital fluency through use. Over time, as trust and usage grew, so did digital familiarity, creating a positive feedback loop for inclusion.

IMPLEMENT

[Collaboration Model](#)

The M-Pesa initiative originated from the social ventures division of Vodafone, which viewed mobile payments as a vehicle for inclusive economic growth. The pilot was jointly funded by Vodafone and the United Kingdom's Department for International Development (DFID), reflecting an early example of international collaboration in digital service innovation (Money, Real Quick, 13). Safaricom led local implementation in partnership with the Commercial Bank of Africa and microlender Faulu Kenya, while development was supported by technical teams in both the United Kingdom and Kenya (Money, Real Quick, 18). This private-sector-led model enabled agile experimentation—with product features refined through iterative feedback loops.

The private-sector approach to M-Pesa allowed for iterative testing, development, and improvement of the service. For instance, the use of a pilot program gave Safaricom critical insights into the breadth of use-cases that M-Pesa offered its customers. Deployed across eight retail locations, each equipped with mobile devices preloaded with M-Pesa software, it enrolled 500 participants who were given mobile phones and stipends to test the platform for loan repayments (Money, Real Quick, 21). However, user behavior quickly demonstrated demand for broader use cases, particularly peer-to-peer transactions. This real-time feedback shaped the platform's evolution from a niche microfinance tool into a general-purpose digital money transfer service.

[Privacy, Security, Protection](#)

Such success did not rely on the private sector alone, as the Central Bank of Kenya enabled key financial structures underlying the entire digital payments technology. The regulatory approach used by the Central Bank of Kenya favored ex post evaluation and regulation, encouraging innovation while protecting its users (Digital Technology and State Capacity, 26). Furthermore, the Central Bank had been involved throughout the development of M-Pesa, soliciting audits of the system’s cybersecurity prior to approval and administering surveys to the Kenyan population to assess trust in and approval of the product (Money, Real Quick, 46).

[Non-discrimination and inclusion](#)

Inclusion was a core feature of M-Pesa’s operational model. Barriers to entry were intentionally low: to register, users needed only a national ID and a Safaricom SIM card (Money, Real Quick, 23). Importantly, access was not restricted to existing Safaricom subscribers—though non-customers faced marginally higher transaction fees.

This approach proved transformative. Remittance flows from urban to rural regions rapidly expanded, providing rural users with a compelling incentive to onboard. The simplicity of the system, combined with its offline SMS interface, made it accessible to previously excluded segments of the population.

[Interoperable and Extensible](#)

Interoperability, however, was a longstanding limitation of M-Pesa. In its initial years, M-Pesa functioned as a closed-loop system, with limited capacity for integration across mobile networks or third-party platforms. Safaricom maintained exclusive control over its payment infrastructure, creating competitive challenges for alternative providers.

It was not until 2016—nearly a decade after launch—that interoperability between digital payment services became mandatory in Kenya (Digital Technology and State Capacity, 31). As a result, while M-Pesa scaled rapidly, its closed architecture initially restricted ecosystem-wide innovation and competition.

[Transparency, Accountability, and Oversight](#)

Oversight of M-Pesa was distributed across several regulatory bodies, including the Central Bank of Kenya, the Communications Authority, and the Competition Authority of Kenya. While this multi-agency model allowed for broader coverage of risk domains, it also led to fragmented responsibilities and at times unclear lines of accountability (Digital Technology and State Capacity, 31).

Despite this, internal governance within Safaricom remained a critical pillar of operational oversight, bolstered by public trust in its brand. The CBK’s test-and-learn approach—though flexible—also introduced trade-offs, as faster innovation carried greater risks of exclusion or unintended harms. Over time, regulatory frameworks have matured to address these early governance gaps and increase

MEASURE

[Enabling Financial Inclusion through Digital Infrastructure](#)

M-Pesa demonstrated immediate and sustained success, registering over 2 million users within its first year of operation—more than double Safaricom’s internal target and far exceeding initial projections (Money, Real Quick, 24). While evaluation frameworks for private-sector initiatives differ from those of government-led DPI systems, M-Pesa’s trajectory offers clear evidence of value creation and developmental impact, particularly for previously unbanked populations.

Over time, M-Pesa evolved from a basic peer-to-peer payments tool into a foundational layer of Kenya’s financial ecosystem, catalyzing new forms of economic participation and digital commerce. Indicators from the Global Findex and FinAccess surveys illustrate the platform’s transformative role in expanding financial inclusion. Between 2006 and 2019, the proportion of Kenyan adults with access to formal financial services rose from 18.9% to 82.9%, reflecting both the direct and spillover effects of mobile money adoption.

In comparative terms, Kenya continues to outperform many peer economies in sub-Saharan Africa on financial access and usage indicators, with M-Pesa credited as a key driver of this progress.

A.2.5 India-Singapore

BACKGROUND

The cross-border payment corridor between India and Singapore has historically been marked by inefficiencies that constrained economic integration and financial inclusion. Traditional remittance channels were costly, often charging fees of up to 5% per transaction, and required several days to settle, creating liquidity challenges for users. The process was especially burdensome for migrant workers and small businesses, who frequently lacked access to streamlined banking infrastructure or financial intermediaries.

Beyond high transaction costs and delays, the operational complexity, ranging from extensive paperwork to the need for multiple banking identifiers, posed a barrier to accessibility for those with limited financial literacy. Given the scale of remittance flows and trade between the two countries, India and Singapore jointly identified the opportunity to design a more efficient, affordable, and inclusive payment architecture, setting a new benchmark for cross-border transactions in the region.

DEFINE

[Addressing Cost and Accessibility Constraints](#)

The joint initiative between India and Singapore was strategically designed to tackle two primary barriers in the cross-border payments space: excessive remittance costs and limited user accessibility. By directly linking India's Unified Payments Interface (UPI) with Singapore's PayNow system, the partnership aimed to deliver a real-time, low-cost, and user-friendly alternative to conventional transfer mechanisms—particularly for migrant workers and underbanked communities who were most impacted by frictions in the legacy system.

[Foundation for Regional Integration](#)

Beyond bilateral efficiency gains, the initiative served a broader strategic objective: to establish a replicable model for regional payment connectivity. As the first real-time system-level integration between two sovereign digital payment platforms, the project reinforced India's position as a regional leader in digital financial infrastructure. It also supported India's longer-term ambitions under Project Nexus and the international expansion of UPI, signaling a shift toward more interoperable, inclusive, and citizen-centric cross-border payment ecosystems across Asia.

IDENTIFY

[Trust](#)

Both India and Singapore entered the integration effort with established legal and institutional frameworks for cybersecurity and data protection, providing a strong foundation for mutual trust. Singapore's Personal Data Protection Act and India's evolving data governance ecosystem created the necessary safeguards to ensure secure handling of sensitive financial information. Both countries had demonstrated experience in operating secure domestic payment systems, with mature protocols for user authentication, end-to-end encryption, and real-time transaction monitoring. This shared regulatory maturity and alignment was a critical enabler for building a cross-border payments platform that met stringent standards of trust, integrity, and resilience.

[Government](#)

The initiative was underpinned by strong public-sector leadership. The Reserve Bank of India and Monetary Authority of Singapore played a central role in governance, coordination, and execution. Both institutions had high implementation capacity with dedicated technical teams and digital transformation experience. A joint governance mechanism was established to oversee the initiative, ensuring clear accountability and operational alignment across jurisdictions.

To operationalize the partnership, the two authorities jointly defined the project's core parameters:

- Establish a real-time, system-level integration between India's Unified Payments Interface (UPI) and Singapore's PayNow platform

-
- Enable seamless transfers using minimal identifiers such as mobile numbers, UPI handles, or Virtual Payment Addresses
 - Connect participating financial institutions through a unified network that ensured secure data flow and transaction execution
 - Build a scalable cloud-based infrastructure capable of supporting increased transaction volumes and future bilateral or multilateral integrations

[Digital Literacy](#)

High smartphone penetration and widespread familiarity with digital payment platforms in both countries supported early adoption and user trust. Singapore's digitally literate population and India's extensive UPI user base created a strong foundation for uptake. Both governments had experience with public awareness and financial literacy campaigns, which facilitated onboarding. However, targeted education efforts were needed to help users understand cross-border functionalities and regulatory distinctions, particularly in relation to currency conversions, transfer limits, and dispute mechanisms.

IMPLEMENT

[Collaboration Model](#)

The UPI–PayNow integration represents a state-led collaboration anchored by the central banking authorities of India and Singapore. The Reserve Bank of India (RBI) and the Monetary Authority of Singapore (MAS) jointly led the initiative, setting regulatory parameters, operational protocols, and technical standards. This bilateral central bank-driven approach ensured strong regulatory governance and institutional accountability from the outset, differentiating it from more market-led models such as M-Pesa.

While government institutions led the initiative, they worked closely with participating financial institutions, including both traditional banks and non-bank financial institutions (like HSBC and DBS), which needed to adapt their systems to support the new payment corridor. The project's funding and governance remained within central bank control, with private sector partners acting as implementation agents rather than strategic decision-makers.

[Privacy, Security, Protection](#)

From the outset, the system was designed with robust security and privacy controls, aligned with the regulatory expectations of both jurisdictions. Implementation included end-to-end encryption, multi-factor authentication, and comprehensive transaction-level auditability, ensuring the integrity and confidentiality of cross-border data flows.

The system implemented sophisticated fraud detection and prevention mechanisms, including real-time transaction monitoring and automated risk assessment. Each country maintained sovereign control over security requirements within their territory while collaborating on shared standards for cross-border

data exchange. Unlike M-Pesa's ex-post regulatory approach, the UPI-PayNow integration incorporated security and privacy by design from inception under close central bank supervision.

[Non-discrimination and Inclusion](#)

The UPI-PayNow linkage was built around a principle of universal accessibility, minimizing friction for users by enabling transfers through mobile numbers or virtual payment addresses instead of requiring complex banking credentials. This user-centered design was particularly impactful for migrant workers and microenterprises, who have historically been underserved by conventional remittance infrastructure.

Both the Reserve Bank of India and the Monetary Authority of Singapore explicitly prioritized equitable access, ensuring that the platform would extend benefits beyond digitally native or financially sophisticated users. The integration ensured 24/7 service availability, reducing barriers linked to time zones and nonstandard work hours. By building on existing domestic payment platforms with high adoption rates, the system reduced the learning curve and encouraged rapid uptake across diverse user segments.

[Interoperable and Extensible](#)

The UPI-PayNow linkage marked a technical milestone in global payment interoperability, representing the first real-time payment systems integration between two countries built on scalable cloud infrastructure. This required sophisticated API integration between the two payment networks, allowing them to communicate seamlessly while maintaining their distinct identities.

The architecture was designed for modular expansion, creating a template for regional and global replication. This strategic foresight has already enabled India to extend UPI-based services to seven additional countries and actively contribute to Project Nexus, a multilateral central bank initiative aimed at advancing cross-border payments in Asia. In contrast to closed-loop systems such as early-stage M-Pesa, interoperability was embedded by design, enabling ecosystem-wide integration over time.

MEASURE

[Socioeconomic Advancement](#)

The UPI-PayNow integration has delivered tangible improvements in the efficiency and affordability of cross-border financial services, particularly for migrant workers and small enterprises. Indian workers in Singapore now save approximately 2.5% in transaction fees compared to traditional remittance methods—translating into higher retained income for families reliant on cross-border support. Small businesses engaged in bilateral trade benefit from faster settlement times, enabling more reliable cash flow and operational predictability. While broader cross-border financial challenges remain, the system has effectively addressed key frictions in affordability and accessibility, demonstrating direct alignment with its public value proposition.

[Public Service Accessibility](#)

By removing the need for extensive documentation and enabling transfers using only mobile numbers or virtual payment addresses, the integration streamlined access to financial services across borders. This simplified user experience has significantly lowered the barrier to entry for less financially literate populations. The platform’s 24/7 availability, irrespective of time zones or institutional operating hours, has further enhanced the responsiveness and inclusivity of financial service delivery.

[Digital Inclusion Impact](#)

Although detailed demographic adoption data is still emerging, early indicators suggest the integration has extended digital finance to previously underserved segments. The use of familiar domestic payment platforms—UPI in India and PayNow in Singapore—reduced onboarding complexity and enhanced trust in the system. By embedding financial inclusion within its core design, the platform contributes to broader digital equity, particularly for users previously excluded from formal financial systems.

[Scalability and Replication](#)

The UPI–PayNow model has demonstrated high replicability and scalability, serving as a reference architecture for regional and global expansion. UPI has since been deployed in seven additional countries, and the bilateral linkage has directly informed Project Nexus, a multilateral effort led by the Bank for International Settlements to connect real-time payment systems across Asia. This regional expansion demonstrates how bilateral DPI collaboration can scale to create broader public value, with plans for implementation in 23 additional countries including major markets like the US, UK, and Saudi Arabia.

Box 4: India and Singapore - From National Innovation to Regional Partnership

India and Singapore each developed sophisticated digital public infrastructure ecosystems independently before pursuing bilateral collaboration. Their successful integration demonstrates how mature national DPI systems can create cross-border value while maintaining sovereign control.

India’s digital transformation began with Aadhaar in 2009, creating what is now the world’s largest biometric identity system serving over 1.3 billion people. This foundational layer enabled India Stack—a comprehensive digital infrastructure including the Unified Payments Interface (UPI), DigiLocker for document verification, and eSign for digital signatures. Launched in 2016, UPI alone now processes over 14 billion monthly transactions, fundamentally transforming India’s payment landscape while driving unprecedented financial inclusion ([UNDP, 2023](#); [Bank of International Settlements, 2024](#); [European Payments Council, 2024](#); [Permanent Mission of India to the UN, 2025](#)). This public-sector-led approach emphasizes open APIs, interoperability, and universal access, establishing India as a global reference for scalable DPI development.

Singapore charted a distinct trajectory, introducing SingPass in 2003 as a unified digital identity gateway that now connects citizens to over 1,400 government services ([Government Technology Agency of Singapore, 2021](#)). The 2017 launch of PayNow enabled instant payments using just mobile

numbers, while MyInfo’s consent-based data sharing reduces form-filling time by 80% through pre-population with verified government data ([Singapore Government Developer Portal, 2021](#)). Singapore’s approach prioritizes regulatory clarity, robust data governance, and seamless user experience, reflecting its emphasis on efficiency and digital trust.

These independently evolved systems—shaped by local contexts, institutional capacities, and citizen needs—converged in 2023 through the UPI-PayNow linkage. This bilateral success reinforces this report’s broader thesis: while DPI increasingly transcends national boundaries, effective international collaboration requires robust domestic foundations first. India and Singapore’s journey from independent innovation to strategic partnership illustrates how countries can extend DPI benefits globally while preserving distinct sovereign architectures - a blueprint for the future of cross-border digital infrastructure.

A.2.6 Brazil

BACKGROUND

The development of Brazil’s Pix instant payment system reflects nearly two decades of incremental reform aimed at modernizing the national financial infrastructure and fostering a more competitive, inclusive, and efficient payments ecosystem. These efforts were grounded in a broader public sector vision to balance innovation with financial stability and expand access to digital finance across the population.

Two pivotal reforms illustrate this trajectory. In 2002, Brazil introduced an instant wholesale payments system, eliminating delays between clearing and settlement and thereby reducing systemic risk across the banking sector. In 2013, the focus expanded to retail payments, culminating in the approval of Act nº 12.865, which extended the regulatory perimeter of the Central Bank of Brazil (BCB) to cover non-financial entities (such as retail stores operating as payment institutions) and lowered market entry barriers for new players.

From 2013 onward, Brazil’s financial sector saw the emergence of new services ranging from unsecured credit to cryptocurrency platforms, spurred by a rapidly expanding fintech and Big Tech ecosystem (including firms like Nubank, Creditas, and PicPay). This proliferation of digital financial services underscored the need for a more adaptive regulatory approach, positioning the BCB as both steward of financial stability and enabler of innovation.

To address this evolving landscape, the BCB convened a Working Group on Instant Payments in May 2018, tasked with developing a payment architecture that would be efficient, secure, competitive, and inclusive. While initially exploring a market-led model, the BCB signaled early on that it was prepared to assume a more active role if needed. By the end of 2018, the central bank released a detailed design framework and declared its intention to operate the new system directly, marking a shift toward state-led infrastructure governance.

This process ultimately led to the creation of Pix, Brazil’s government-operated instant payment system, which launched in November 2020 and quickly became one of the world’s most successful examples of public sector-led digital payments infrastructure ([Pix Management Report, 2023](#)).

The need to modernize and reorganize the financial market led the BCB to propose the creation of a Working Group (WG) on instant payments. Starting in May 2018, the WG aimed primarily to discuss with market players and experts the creation of an “efficient, competitive, secure, and inclusive instant payments ecosystem”. While initially favoring a market-driven approach, the BCB signaled its readiness to take an active regulatory role if necessary. By December 2018, the BCB released key requirements for an instant payment system, positioning itself as the system’s operator. [This initiative led to the creation of Pix, which was officially launched in November 2020.](#)

DEFINE

The Central Bank of Brazil (BCB) launched Pix with a clearly articulated goal: to accelerate the adoption of digital payments in order to improve economic efficiency and reduce the country’s overreliance on cash, particularly in the retail payment market. The initiative formed part of a broader effort to modernize Brazil’s financial ecosystem, enhance user experience, and expand access to affordable, inclusive payment infrastructure.

[Reduce cash dominance](#)

As of 2019, cash remained the dominant payment method in Brazil, accounting for approximately 77% of all financial transactions. This reliance on physical currency imposed significant economic costs—including those associated with production, storage, transportation, security, and destruction, costs which were often passed on to consumers and merchants through higher service fees. Beyond cost, cash limited financial inclusion by restricting access to digital services, impeding participation in e-commerce, and complicating installment-based purchases, which are increasingly common in Brazil’s consumer landscape.

[Economic efficiency](#)

BCB’s diagnostic analysis identified persistent inefficiencies across existing retail payment methods. Legacy systems such as checks, DOCs, and *boletos* were characterized by slow processing times and delayed fund availability. More modern options, such as credit and debit cards, involved high merchant fees, device-specific requirements, and limited reach. Fragmented infrastructure and low levels of interoperability further constrained market efficiency, often requiring complex agreements for cross-institution transactions. User experience remained a key barrier: many existing systems demanded excessive manual input, lacked intuitive interfaces, and offered limited support for real-time peer-to-peer transactions.

IDENTIFY

[Trust](#)

At the time of Pix's development, Brazil lacked a dedicated data protection law or a national cybersecurity framework. The General Personal Data Protection Law (LGPD) would not come into effect until 2020, and a national cybersecurity law was only introduced in 2023. However, Brazil maintained a solid foundation in consumer protection and rights-based standards, which provided an initial baseline for digital trust. These frameworks were gradually adapted to the emerging digital environment.

How Trust Affects Usage

In early 2025, the Pix usage rates experienced a decline following the spread of misinformation suggesting that the government intended to tax Pix transactions ([Bloomberg, 2025](#)). This false narrative emerged after the Federal Revenue Service introduced a regulation mandating financial institutions to report transactions exceeding R\$5,000 for individuals and R\$15,000 for businesses, aiming to enhance financial transparency and combat illicit activities. Despite official clarifications that no new taxes were being imposed, the misinformation rapidly disseminated across social media platforms, leading to public apprehension and a noticeable drop in Pix usage. In response to the public outcry and to reaffirm the system's cost-free nature, the government revoked the regulation and issued a provisional measure to reinforce that Pix transactions remain free of charges.

[Government](#)

Pix's development was enabled by a technically strong and institutionally independent Central Bank of Brazil (BCB). Although the initiative coincided with a change in presidential leadership in 2019, the institutional credibility of the BCB remained intact. Legislative reforms granting autonomy to the Central Bank, including fixed terms for the president and directors, strengthened public confidence and insulated the initiative from political shifts.

The BCB's leadership reflected nearly two decades of incremental reform and capacity-building. Through its dedicated technical teams and inclusive development process, the BCB engaged both established stakeholders and new entrants, consolidating broad-based support for Pix. This strategic alignment ensured that Pix would be not only technically robust but also institutionally resilient.

[Markets](#)

Brazil's financial market was historically dominated by a few large incumbents—Itaú, Bradesco, Banco do Brasil, and Caixa Econômica Federal—with concentrated market share. However, by the 2010s, market dynamics began to shift. A new wave of fintechs and digital-first financial institutions, such as Nubank,

PicPay, and Creditas, brought disruptive energy into the ecosystem, paving the way for expanded service offerings and increased competition.

Though Brazil's overall innovation landscape remained uneven across sectors, financial services consistently ranked among the country's most digitally mature industries, attracting experienced professionals and capital investment. According to McKinsey, the sector outpaced others—including healthcare and public administration—in terms of digital transformation readiness, providing fertile ground for Pix's introduction.

[Infrastructure](#)

By 2019, 84% of Brazilian households had internet access, with significant gains in rural connectivity ([Serviços e Informações do Brasil](#)). Rural internet penetration reached 57.8%, reflecting a steady expansion of the digital infrastructure needed to support inclusive financial access. The continued deployment of mobile networks and expansion of broadband services provided the technical backbone for real-time payment solutions like Pix to scale across the country.

[Digital literacy](#)

Brazil's population demonstrated high levels of digital engagement, particularly through social media. This widespread digital fluency created a user base already comfortable with mobile technologies and digital platforms. Since 2013, the growth of Brazil's fintech ecosystem had familiarized millions with mobile-first financial tools, setting the stage for the mainstream adoption of Pix. Companies like Nubank and PicPay had not only broadened access to financial services but also shifted public expectations toward faster, more convenient digital transactions, enhancing readiness for national DPI systems.

IMPLEMENT

[Collaboration model](#)

Pix was developed through a highly coordinated public-sector-led process, with the Central Bank of Brazil (BCB) serving as both system operator and regulator. Beginning in 2018, the BCB convened structured dialogues with financial institutions, fintechs, and other stakeholders to shape a shared vision for an inclusive, instant payment ecosystem. Following the establishment of the legal framework in 2020, Pix underwent a phased rollout that included trial operations and stakeholder onboarding to ensure institutional readiness and public awareness.

Pix has been described as a "state-owned fintech"—a public digital infrastructure managed with the agility of a startup ([SciELO Brazil, 2023](#)). The BCB's decision to lead both operation and governance enabled first-mover advantage and platform coherence. In a notable example of ecosystem stewardship, the government delayed the rollout of WhatsApp Pay shortly before Pix's launch, out of concern that a private alternative could fragment the payments landscape, entrench Meta's market share, and dilute

Pix's network effects. To ensure long-term financial sustainability, the BCB introduced a modest transaction fee for regulated institutions, allowing Pix to operate independently of fiscal budget cycles.

The development and implementation of Pix were carried out through close collaboration with market participants and a phased introduction strategy. Discussions with stakeholders began in 2018, and after the legal framework was established in 2020, Pix underwent trial operations before its full-scale launch. To ensure transparency, accountability, and oversight, BCB established unified guidelines for all participants and implemented mechanisms to enable immediate transaction recording and traceability.

[Technical Implementation](#)

Pix's architecture is anchored in two foundational components: the Instant Payment System (SPI) and the Directory of Transactional Account Identifiers (DICT). These systems enable secure, real-time transactions 24/7 and support alias-based payments using phone numbers, emails, or personal identification numbers. Open APIs allow banks, fintechs, and other financial service providers to connect seamlessly, fostering competition and innovation.

To participate, non-bank institutions must partner with regulated entities, preserving systemic integrity while expanding access. Participants are required to build private infrastructure that complies with technical and security requirements established by the BCB. Pix incorporates a layered security framework, including biometric authentication, transaction encryption, and two-factor authentication. The system features proactive fraud controls, such as the Special Refund Mechanism (MED) and transaction limits. These measures support real-time fraud detection, user protection, and systemic trust.

Moreover, Pix is deliberately designed to enhance financial inclusion. Non-bank payment providers, digital wallet operators, and small financial institutions can all participate, allowing users without traditional bank accounts to access fast, low-cost digital payments. Public sector institutions use Pix for tax refunds, benefit disbursements, and government fee payments, embedding the system across both public and private services.

With its comprehensive governance model, extensible technical architecture, and inclusive access mechanisms, Pix has become Brazil's dominant payment method and a cornerstone of its digital economy.

MEASURE

[Economic Efficiency](#)

The widespread adoption of Pix resulted in cost savings of \$5.7 billion for businesses and consumers in 2021, generating an additional economic impact of \$5.5 billion, which represents 0.34% of Brazil's GDP. Since its introduction in November 2020, the number and volume of transactions have grown rapidly. By December 2022, the number of transactions conducted via Pix reached 2.9 billion, marking an increase

of 1,900% compared to December 2020. Additionally, the total transaction volume grew by 914% over 24 months, reaching R\$1.2 trillion in December 2022.

While Pix is primarily used for peer-to-peer (P2P) transactions, corporate adoption has steadily increased. In November 2020, 87% of transactions were P2P, but as businesses adapted their systems, the share of person-to-business (P2B) payments increased from 5% in November 2020 to 24% in December 2022. Business-to-business (B2B) transactions, in particular, involve larger transaction values, with the average B2B transaction amounting to R\$5.7 thousand in December 2022, significantly exceeding the average P2P transaction of R\$257. This reflects the nature of commercial transactions, and B2B transfers have grown to account for 36% of the total transaction volume.

[Reduce cash dominance](#)

Pix has also catalyzed a rapid shift away from cash. Cash use in point-of-sale (POS) transactions fell from 79% in 2018 to 48% in 2024, according to Statista ([statista](#)). The transaction value of cash fell from 68% in 2014 to just 17% in 2024, while account-to-account (A2A) payments now lead in both e-commerce and retail contexts. This transition reflects the broader efficiency and convenience gains facilitated by Pix.

International Expansion

The BCB has positioned Pix as a regional platform for cross-border payments. Partnerships with fintechs like PagBrasil and B89 have enabled merchants in Uruguay, Argentina, Paraguay, Colombia, and other Latin American countries to accept Pix payments in Brazilian reais. Exchange rates are locked in at the time of purchase, reducing uncertainty for consumers and merchants alike. In Paraguay alone, over 35,000 businesses now accept Pix, boosting cross-border commerce and economic integration.

These efforts reflect the BCB's broader ambition to position Pix as a catalyst for regional financial interoperability, further advancing Brazil's leadership in digital payments.

A.2.7 Mexico

BACKGROUND

Mexico's experience with the X-Road platform offers a subnational contrast to Estonia's nationally coordinated model. While Estonia benefited from two decades of cohesive policy, centralized governance, and sustained citizen trust, Mexico's attempted X-Road implementation in the state of Querétaro reflects a more fragmented, state-led approach with limited national coordination.

In 2022, the State of Querétaro launched the Plataforma de Interoperabilidad, a digital transformation initiative aimed at modernizing administrative workflows and improving the efficiency of public service delivery. The platform was developed under the Querétaro Digital 2022–2027 roadmap and drew direct

inspiration from Estonia’s X-Road model, leveraging its open-source architecture to establish a foundational data exchange layer for state institutions.

The initial deployment focused on streamlining social benefits administration and improving coordination among local agencies. However, the pilot remained geographically and functionally limited, lacking the federal mandates, institutional scale, and long-term policy coherence seen in Estonia. Unlike Estonia’s nationwide strategy, Querétaro’s effort was driven by state-level leadership, with minimal integration into a broader national interoperability agenda.

The platform’s development was thus primarily shaped by local priorities and resource constraints, positioning it more as a proof-of-concept than a fully institutionalized DPI system. Nonetheless, it offers insight into the challenges of implementing digital public infrastructure in federated systems without strong national coordination.

DEFINE

Mexico’s digital public infrastructure (DPI) trajectory reflects a patchwork of initiatives marked by limited policy integration and uneven implementation capacity. While progress has been made in areas such as data protection, cybersecurity, and financial digitalization, systemic barriers—including fragmented infrastructure, interoperability gaps, and inconsistent digital literacy—continue to constrain nationwide progress. According to the UNDP Digital Development Compass, Mexico is in a “systematic development” phase: digital governance frameworks are in place, but operationalization at scale remains limited.

Against this backdrop, the State of Querétaro launched the Plataforma de Interoperabilidad in 2022 as part of its broader Querétaro Digital 2022–2027 strategy. Drawing inspiration from Estonia’s X-Road model, the initiative sought to unify disparate information systems across state agencies and improve the efficiency of service delivery through real-time data exchange.

Positioned within the state’s cross-cutting digital action plan ([Plan de Acción Transversal](#)), the platform aimed to establish a technical foundation for interoperability. However, unlike Estonia’s tightly coordinated national model, Querétaro’s effort emerged as a stand-alone pilot—anchored in local leadership and open-source adaptability, rather than national policy alignment or institutional mandates.

[Efficiency](#)

Mexico’s initiative was primarily driven by a desire to improve the efficiency of government services, especially in fragmented areas like benefits administration. However, while efficiency was a recognized priority, it was not part of a clearly defined, measurable national goal. Many government processes remain analog across federal ministries, and while the Querétaro pilot sought to reduce administrative redundancy, there was no centralized tracking of time savings or service delivery KPIs.

Mexico's Digital Strategy 2021–2024 references general efficiency ambitions, but lacks baseline benchmarks or clarity on how digital transformation translates to citizen outcomes. Unlike Estonia's tight link between national information policy and implementation, Mexico's digital vision remains disjointed between state and federal levels.

[Interoperability](#)

Interoperability was a technical feature rather than a foundational principle. The choice of X-Road was influenced by its open-source flexibility. While Querétaro's project aimed to link disparate local databases, no formal mandate or incentive structure existed to expand integration across federal ministries. This means that even though the state-level implementation of X-Road technically allowed for secure data exchange, there were no national architectural standards or enforcement mechanisms to ensure extensibility—something Estonia built early on.

IDENTIFY

Mexico's digital ecosystem reflects a complex interplay of regulatory progress and operational constraints. Between 2020 and 2022, national assessments highlighted uneven development across trust, infrastructure, institutional capacity, and digital literacy—critical enablers in any DPI deployment.

[Trust](#)

Public trust in government remains low, with just 17.4% of citizens expressing confidence in state institutions ([Our World Data Initiative](#)). According to statistics from Our World Data Initiative, trust levels in banks (35.1%) and large corporations (32.2%) are comparatively higher. This dynamic suggests that private sector participation in DPI implementation may not be viewed with skepticism by the public and could even enhance legitimacy. However, the limited trust in public institutions presents a structural challenge to scaling DPI models that depend on centralized governance or state-led user engagement.

[Government](#)

Mexico has enacted robust legal frameworks in areas such as consumer protection, data privacy, and human rights, reflecting strong regulatory intent. However, implementation capacity remains uneven. Despite relatively strong performance in digital public service design and open government principles, Mexico scores below average in government effectiveness (2.33/5), indicating persistent delivery bottlenecks. The country also scores low across business environment and innovation ecosystem indicators, limiting the emergence of domestic market actors who could accelerate DPI growth through public-private collaboration.

In this context, Querétaro's reliance on open-source platforms and localized governance was a pragmatic response to limited federal coordination and domestic vendor maturity.

[Infrastructure](#)

Mexico demonstrates broad internet coverage, but quality of access remains a concern. UNDP assessments show low affordability and suboptimal broadband speeds. Within Querétaro, approximately 80% of the population has internet access and mobile coverage, yet only 42% report using computers, suggesting a usage gap despite physical connectivity. This may limit citizen engagement with more complex digital platforms unless accompanied by targeted outreach or support.

[Digital literacy](#)

National indicators for digital skills and adoption are slightly above average, but usage remains inconsistent. A particularly low score for graduates in STEM or computer science (1.54/5) suggests a constrained talent pipeline for building and maintaining digital infrastructure. These limitations raise questions about long-term technical sustainability and may hinder the scaling of platforms like Querétaro's X-Road implementation.

IMPLEMENT

[Collaboration Model](#)

Mexico's X-Road deployment in Querétaro illustrates a decentralized, state-led approach to DPI implementation, marked by fragmented coordination and constrained institutional capacity.

The initiative was launched in 2022 under the Querétaro Digital 2022–2027 strategy, led by the Directorate of Administrative Services and Technological Infrastructure and the Center for Information and Analysis for Security. The government selected X-Road for its open-source flexibility and engaged Estonian firm Roksnet for technical support. Within six months, the pilot went live, initially focusing on social benefits administration through real-time data exchange between state agencies. With real-time data exchange facilitated among different agencies, the solution deployed would overcome the obstacle of data silos. The system streamlined access to public aid by maintaining updated and accurate citizen records, enhancing inter-agency collaboration.

[Technical Implementation](#)

According to [X-Road's website](#), several challenges appeared along the way. Firstly, it mentions that changes in decision-making caused the project to not enjoy the same support as when it first started. However, the state election was conducted in 2021, and the elected governor, Mauricio Kuri, holds office from 2022 to 2027. The state's digital strategy also runs from 2022 to 2027, so there should be no problems regarding changes in decision-making. [X-Road's website](#) also mentions that there were technical challenges in integrating X-Road with the existing IT infrastructure while ensuring compatibility across different government bodies:

“There was a learning curve associated with adopting the open-source platform. Simply because specific technical expertise was required, as well as ongoing management and customization, that were not readily available within the local teams”.

Despite a very quick implementation phase - only six months - it seems like the project was interrupted. According to the [state's government official website](#), only 50% of the project was completed.



Status of Project: 2025

The implementation of X-Road in Mexico, specifically in the state of Querétaro, reflects a decentralized, government-led approach marked by fragmented coordination and limited institutional capacity. Initiated in 2022 under the state’s “Querétaro Digital 2022–2027” strategy, the X-Road pilot—locally referred to as Plataforma de Interoperabilidad—sought to modernize public administration and integrate disparate databases across state ministries. The project was spearheaded by the Directorate of Administrative Services and Technological Infrastructure and the Center for Information and Analysis for Security, both of which operated within the state government. Despite this clear leadership, the implementation was largely isolated within Querétaro and lacked a strong federal mandate or cross-state replication strategy, which significantly limited its national impact.

Unlike Estonia’s nationally coordinated public-private partnership, Mexico’s implementation lacked consistent engagement with private sector stakeholders and relied primarily on public institutions for technical development. The Mexican government selected X-Road primarily for its open-source framework and flexibility, citing these features as key to avoiding vendor lock-in and reducing costs—yet this decision was made without sufficient internal technical capacity or long-term budget planning. A 2023 review by the Centro de Investigación y Docencia Económicas (CIDE) observed that the absence of centralized governance mechanisms has resulted in inconsistent implementation and limited knowledge transfer across agencies ([CIDE Report, 2023](#)).

Moreover, implementation progress has been hampered by bureaucratic inertia, limited interoperability across existing federal platforms, and the lack of a nationwide digital identity system, which could serve as a foundational layer for X-Road's data exchange functionality. According to the 2023 UN E-Government Survey, although Mexico scores relatively well on the Online Services Index (OSI), its performance in the Human Capital and Telecommunication Infrastructure sub-indices trails behind regional leaders, reinforcing the unevenness of digital public infrastructure at the national level ([UN E-Government Survey, 2023](#)).

Financial constraints have further limited Mexico’s ability to scale the project beyond Querétaro. While the initial pilot focused on enabling access to social benefits databases, it has not been expanded to other states or integrated with core federal systems such as SAT (Tax Administration Service) or the IMSS (Mexican Social Security Institute). As noted in a policy brief by IT Now, the absence of interoperability standards and the low rate of data sharing between ministries remain persistent barriers ([IT Now, 2023](#)). Finally, while Querétaro has demonstrated political will at the state level, the lack of cohesive national leadership, stable funding, and institutional alignment continues to limit the scope and long-term sustainability of Mexico’s X-Road implementation. This decentralized and state-driven model highlights key gaps in collaborative governance, especially when contrasted with more mature DPI ecosystems that leverage whole-of-government approaches and structured partnerships to drive implementation forward.

MEASURE

According to the [state’s official website](#), the success of the project was to be measured using one metric: the number of citizens covered by the interoperability platform (Sumatoria de ciudadanas y ciudadanos interoperados en la Plataforma). No official documents could be found with its results. Since the project was not completed, there is no available information about the initial goal, to enhance service delivery efficiency.

[Interoperability](#)

To date, Mexico’s implementation of X-Road in Querétaro has fallen short of achieving its stated goals, particularly in terms of measurable citizen outcomes and system-wide efficiency gains. Unlike Estonia’s iterative approach—where each stage of X-Road development included robust impact tracking and service expansion metrics—Mexico lacks clear benchmarks, standardized performance indicators, and consistent public reporting mechanisms to evaluate progress. Although government actors have expressed ambitions to improve public service delivery through the Plataforma de Interoperabilidad, little has been done to assess whether these ambitions have translated into improved citizen experiences or operational efficiencies.

[Efficiency](#)

In terms of streamlined public service delivery, there is also a lack of transparency regarding system uptime, cross-agency interoperability rates, or citizen satisfaction with X-Road-enabled services. A 2023 report by the [Inter-American Development Bank \(IDB\)](#) found that Querétaro’s government still relies heavily on paper-based transactions for many services, with limited uptake of digital alternatives in rural areas. The pilot did not include service-level agreements (SLAs) or user feedback loops, and citizen engagement in system design has been minimal. As a result, service improvements remain anecdotal, and the absence of digital monitoring tools hampers performance measurement across departments.

Taken together, these gaps in measurement and evaluation highlight a critical weakness in Mexico’s X-Road implementation. While the initiative may hold long-term potential, its current status as a

state-led pilot with no systematic outcome tracking suggests that key goals—economic equity, efficient service delivery, and digital inclusion—have not yet been achieved. Without clear metrics, transparent reporting, and inclusive design, the program remains difficult to scale and even harder to evaluate in terms of impact.

A.2.8 China

BACKGROUND

Launched in 2018 by the Guangdong Provincial Government, Yue Sheng Shi (粤省事) stands as one of China’s most advanced examples of state-led Digital Public Infrastructure (DPI). Developed as a mobile-based “super app,” it provides unified access to more than 1,300 public services—including healthcare, education, taxation, transportation, and legal affairs—consolidating previously siloed government functions into a single digital interface.

The platform is fully government-funded, designed, and operated, with interoperability and data governance managed by the Guangdong Provincial Big Data Administration and the Department of Government Services. Unlike many DPI systems globally that rely on donor support or public-private partnerships, Yue Sheng Shi reflects a centralized, sovereign model, aligned with China’s national Digital China strategy. It serves as a blueprint for provincial integration under a broader vision of platform-based governance and digital service delivery.

DEFINE

[Efficiency](#)

Yue Sheng Shi was designed to streamline public service delivery across Guangdong Province by providing citizens with a seamless, “one-stop, one-click” experience. The initiative aimed to overcome longstanding challenges associated with fragmented portals, bureaucratic delays, and unequal access to services, particularly in rural areas.

From inception, the platform prioritized efficiency, convenience, and scale. Unlike traditional government websites focused solely on information dissemination, Yue Sheng Shi enables real-time transactions—ranging from renewing identity documents and scheduling medical appointments to paying fines and accessing vaccination records. These design elements reflect a shift from departmental portals to a life-event-based model of service delivery.

The platform was also conceived as a tool to enhance transparency and reduce opportunities for administrative discretion by minimizing the need for in-person approvals. Aligned with national and regional strategies such as Digital China and Smart Guangdong, Yue Sheng Shi was positioned as both a provincial innovation and a potential national model for scalable digital governance.

IDENTIFY

The rapid deployment and adoption of Yue Sheng Shi were supported by a strong foundation of enabling conditions consistent with key pillars of DPI development—namely, institutional trust, government capacity, infrastructure, and digital literacy. As one of China’s most economically dynamic provinces, Guangdong offered both the technical readiness and policy alignment necessary to launch a province-wide digital services platform.

[Trust and Political Legitimacy](#)

In China, state-led digital platforms benefit from relatively high levels of institutional trust in government-provided technology. Citizens are accustomed to using government-developed platforms (e.g., State Council App, Health Codes during COVID-19) and typically view them as authoritative and secure. This trust in the state as a digital service provider made Yue Sheng Shi more credible than privately developed apps attempting similar integration. Furthermore, public communication campaigns by the Guangdong government emphasized the app’s security, convenience, and accessibility, helping to build widespread acceptance.

[Government](#)

Yue Sheng Shi was executed by a highly capable provincial administration with strong cross-agency coordination capacity. The Guangdong Department of Government Services and Big Data Administration played a central role in mobilizing local governments, enforcing onboarding mandates, and ensuring vertical and horizontal interoperability. Critically, the platform was embedded in national policy frameworks such as Digital China and Smart Guangdong, securing sustained political backing.

[Infrastructure](#)

Guangdong’s robust digital infrastructure—including high mobile internet penetration (above 80%), widespread 4G/5G coverage, and early investment in cloud computing and data centers—enabled large-scale service delivery via smartphones ([CNNIC, 2023](#)). These backend systems supported secure, real-time data exchange and positioned the province to meet the technical demands of integrated digital governance.

[Digital literacy](#)

Strong digital literacy among residents accelerated adoption. Over 94% of internet users in China access services via mobile apps ([iResearch, 2022](#)), and Guangdong’s digitally engaged population—familiar with mobile payments, e-commerce, and digital identity tools via platforms like WeChat—encountered minimal friction in onboarding. The province’s tech-savvy youth and urban density further reduced the learning curve.

IMPLEMENT

The implementation of Yue Sheng Shi represents a textbook example of state-led DPI, characterized by centralized funding, hierarchical governance, and direct administrative integration across public agencies. The platform was developed under the leadership of the Guangdong Provincial Department of Government Services and Big Data Administration, with technical support from state-designated digital infrastructure contractors and provincial IT research institutes.

[Collaboration Model](#)

Yue Sheng Shi reflects a centralized, state-led implementation approach, with development overseen by the Guangdong Provincial Department of Government Services and Big Data Administration. Technical execution was carried out in collaboration with provincial IT research institutes and state-designated infrastructure providers. Unlike public-private partnership models, the platform is fully government-owned, operated, and maintained, with end-to-end control retained by public authorities ([Guangdong Provincial Government, 2020–2023](#)).

Although Yue Sheng Shi is state-owned, private-sector actors—primarily local IT firms and SOEs (e.g., China Telecom, Huawei Cloud, or Tencent Cloud)—were engaged as technical contractors, not strategic partners. Their role was limited to infrastructure provision and backend integration, under strict data security and platform standards. No private companies had governance or data ownership rights. This approach maintained governmental data sovereignty while leveraging technical capacity from the domestic tech ecosystem.

[Technical Implementation](#)

Yue Sheng Shi was designed using a modular, API-based architecture, allowing departments to plug into the central app using standardized interfaces. It is interoperable with China's national Unified Government Service Platform and is tightly integrated with real-name authentication systems (such as national eID and facial recognition systems). Data is exchanged securely through provincial-level data centers, which operate under China's Cybersecurity Law and government cloud policies. The backend supports both vertical (province-to-city-to-county) and horizontal (across sectors) information flows, a feat enabled by the early development of Guangdong's Unified Data Sharing and Exchange Platform.

Implementation was mandated through administrative orders, requiring all provincial, municipal, and county-level departments to onboard their services onto the platform. Performance benchmarks were written into civil servant performance evaluations, incentivizing rapid digital migration. Additionally, each agency was responsible for maintaining service accuracy and usability, under supervision from the central digital governance team.

MEASURE

The success of Yue Sheng Shi has been widely recognized both within China and in comparative digital governance studies. As of 2023, the app has achieved over 50 million registered users, with over 2 billion cumulative service transactions, and over 95% of provincial-level government services available online or

via mobile ([Guangdong e-Government Bulletin, 2023](#)). It has become the de facto “digital front door” for citizens to interact with all levels of government in Guangdong.

[Service Delivery Metrics](#)

As of 2023, Yue Sheng Shi integrates over 1,300 public service items, spanning areas such as health insurance claims, education subsidies, legal document access, household registration, and elderly care services. The platform has logged over 2 billion cumulative service transactions, with an average monthly active user base of over 30 million (Guangdong e-Government Bulletin, 2023). The digitalization rate of core provincial-level services has reached over 95%, and 85% of these can be completed fully online without in-person visits.

[Citizen Impact and Inclusion](#)

User surveys conducted by the Guangdong Provincial Government report over 90% satisfaction rates, citing reduced queuing time, simplified documentation, and 24/7 mobile accessibility. The platform has extended to rural and elderly populations through offline support terminals in local community centers, libraries, and hospitals. Over 200,000 village-level service agents have been trained to assist with app usage, narrowing the digital divide in remote areas ([Digital Guangdong Progress Report, 2022](#)).

[Operational Efficiency](#)

A [2022 performance](#) audit by the Guangdong Provincial Audit Office reported that Yue Sheng Shi reduced administrative processing time by an average of 35% across services where digital migration was complete. This translated into both financial savings for the government and reduced indirect costs for citizens (e.g., lost wages from time off work). Departments using the app for workflow management also reported lower incidence of data loss, redundant form submissions, and human error.

A.2.9 South Africa

BACKGROUND

M-Pesa, the mobile money platform launched in Kenya in 2007 by Vodafone and Safaricom, emerged as a groundbreaking tool for financial inclusion, enabling millions of unbanked individuals to send and receive funds via mobile devices. Building on this success, Vodafone’s South African subsidiary, Vodacom, introduced M-Pesa to the South African market in 2010, aiming to replicate the Kenyan model.

Despite high expectations, the initiative was discontinued in 2016 after failing to reach sustainable adoption levels. South Africa, one of the continent’s most technologically advanced economies, presented a very different operating context. Mobile penetration exceeded 90%, with significant smartphone ownership, yet M-Pesa struggled to gain traction ([BBC Africa Business Report, 2016](#)). Unlike Kenya or Tanzania, South Africa already had a mature banking infrastructure—approximately 75% of

adults had access to formal financial services at the time of launch—diminishing the platform’s relevance as a tool for financial access (FinMark, 2016).

This case underscores the importance of contextual alignment in digital public infrastructure (DPI) deployment. While M-Pesa successfully addressed structural gaps in East Africa, its direct transplantation into a different regulatory, institutional, and financial landscape revealed critical limitations. South Africa’s experience illustrates that DPI solutions must be tailored to local conditions to achieve meaningful and sustained impact.

DEFINE

[Financial Inclusion](#)

The central goal of M-Pesa in South Africa was to promote financial inclusion by offering mobile-based financial services to the unbanked and underbanked population. However, unlike Kenya, where M-Pesa filled a critical void, South Africa already had broad financial access and well-established banking networks. The initiative lacked a clearly defined unique value proposition within the South African context.

The goal definition was generic and lacked contextual alignment with the country’s socioeconomic and financial landscape. Unlike Kenya, where M-Pesa’s rollout was tightly focused on solving a specific structural gap, the South African version of M-Pesa failed to clearly articulate a citizen-centered objective, and no baseline measurement indicators were established to track the program’s progress or user impact.

IDENTIFY

The failure of M-Pesa in South Africa can be attributed to several contextual factors related to infrastructure, government involvement, market conditions, and trust. Although South Africa possessed the technical infrastructure to support a mobile money platform, misalignment between enabling conditions and user needs significantly constrained adoption.

[Infrastructure](#)

Infrastructure in South Africa was highly developed by 2010, with [reliable mobile network](#) coverage and widespread access to financial institutions. Mobile penetration was above 90%, and smartphone adoption was already growing, offering a strong technical foundation for mobile financial services. However, the physical financial infrastructure was equally robust—most urban and rural populations had access to ATMs and bank branches within a 20 km radius. This meant that M-Pesa’s core value proposition—offering access where banks were absent—was largely irrelevant in the South African context.

[Digital literacy](#)

Digital literacy and usage patterns presented another major challenge. Although mobile phone usage was widespread, South African consumers primarily used mobile technology for voice communication and leisure, not for financial management. There was limited cultural precedent or consumer demand for using mobile phones as financial instruments. Unlike Kenya, where mobile money was seen as an empowering alternative to cash, in South Africa, traditional banking was seen as more stable, accessible, and trustworthy.

[Market conditions](#)

Market conditions also posed structural hurdles. South Africa's banking sector is one of the most advanced in Africa, offering sophisticated services even to low-income groups. Approximately [75% of adults](#) held bank accounts, and government grants were directly deposited into these accounts, eliminating the need for alternative cash-out or transfer mechanisms. Banks were also expanding their own digital platforms, making M-Pesa redundant rather than complementary. Additionally, Vodacom's partner, Nedbank, was perceived as a bank for middle- and high-income customers, alienating the very demographic M-Pesa was supposed to serve.

[Trust and ecosystem alignment](#)

Trust and ecosystem alignment were limited. M-Pesa in South Africa did not evolve from a public-private dialogue or government-supported digital inclusion strategy. Instead, it was driven by Vodacom as a private-sector initiative, without sufficient partnership from public agencies or grassroots financial education campaigns. This lack of ecosystem coordination and government support—in contrast to Kenya's regulatory backing and Safaricom's near-monopoly on telecom—undermined public confidence and failed to create a conducive environment for adoption.

IMPLEMENT

[Collaboration Model](#)

The implementation of M-Pesa in South Africa was largely private-sector led, spearheaded by Vodacom, the country's largest mobile operator, in partnership with Nedbank, one of South Africa's major banks. Unlike in Kenya, where M-Pesa emerged through iterative adjustment leading to widespread grassroots usage, its South African rollout was built on a commercial strategy without sufficient integration into the public financial ecosystem or alignment with user needs.

Vodacom's choice to partner with Nedbank proved to be a strategic misstep. Although Nedbank is a reputable institution, it primarily serves middle- and high-income consumers who already have access to robust banking services. This partnership did little to reach South Africa's unbanked population or to

build the kind of trust and accessibility that M-Pesa relied on in other African countries. The absence of partnerships with community banks, cooperatives, or social service agencies further limited M-Pesa's reach among its intended demographic.

Technical Implementation

In terms of service model, M-Pesa was implemented through a standard digital wallet approach, allowing users to send and receive money via mobile phones. However, unlike in Kenya, the network of agents for cash-in and cash-out services was underdeveloped, and registration processes were seen as cumbersome. The product lacked integration with local use cases, such as bill payments, government transfers, or informal savings groups, which are critical for adoption in underserved communities.

Moreover, South Africa's regulatory environment did not evolve to support mobile money as a separate category distinct from traditional banking. Because of the country's stringent financial regulations, Vodacom had to operate M-Pesa through a formal banking partner. This increased compliance complexity and hindered the platform's agility, while the central banking infrastructure continued to dominate payment services across the country.

Lastly, there was no strong national digital financial inclusion strategy to amplify M-Pesa's relevance or adoption. In contrast with Kenya's coordinated public messaging and civil society support for mobile money, the South African implementation lacked both policy alignment and public education, resulting in minimal awareness and trust.

MEASURE

The clearest indicator of implementation failure was the platform's low user uptake. Despite Vodacom's goal of reaching 10 million users within three years, by 2016—six years post-launch—[only 76,000 active users](#) had adopted M-Pesa, a fraction of the projected user base. While millions had registered, the vast majority never transacted regularly, indicating weak engagement and retention.

Another measurable shortcoming was the platform's failure to achieve critical mass. In mobile money ecosystems, network effects are key: the more users adopt the platform, the more valuable it becomes. However, because South Africa already had a high rate of formal bank account ownership (75%), most consumers saw little added value in switching to M-Pesa. This was compounded by limited agent coverage, narrow service options, and no perceived cost or convenience advantage.

In terms of financial ecosystem impact, M-Pesa did not significantly extend financial inclusion in South Africa. There is no evidence that it reduced the number of unbanked adults, expanded access to government services, or increased mobile payments in rural or underserved regions. The platform also failed to trigger broader fintech innovation, which was beginning to gain momentum independently through banks' own mobile apps.

Finally, the project lacked meaningful user feedback mechanisms, performance metrics, or government evaluation frameworks. The absence of transparent data on adoption barriers, user experience, or inclusion outcomes made it difficult to adapt the platform based on real-world conditions.

By 2016, Vodacom publicly acknowledged the platform's failure and discontinued M-Pesa in South Africa, marking it as a cautionary tale: a well-funded, technically sound solution that failed due to poor contextual fit, weak institutional alignment, and lack of user-centered design.