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DIGITAL PUBLIC INFRASTRUCTURES (DPIS): WHAT IMPLICATIONS FOR DEVELOPMENT AND MSME ECOMMERCE?

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DIGITAL PUBLIC INFRASTRUCTURES (DPIS): WHAT IMPLICATIONS FOR DEVELOPMENT AND MSME ECOMMERCE?

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I. INTRODUCTION

In recent years, there has been growing discussion on “digital public infrastructures” (DPIs), or technological systems and services that are publicly owned or managed by government entities and implemented at national scale, typically to promote inclusive digital development and delivery of public services to citizens. DPIs include payments infrastructures, identity systems, and data exchanges. Some prominent examples include India’s Aadhar biometric digital identity system, India’s Universal Payment Interface (UPI), and Mauritius’s InfoHighway and Estonia’s X-Road data exchanges for citizens to access public services and interact with their government.¹ DPIs are envisioned as building blocks for technology solutions that provide services to citizens, such as healthcare and insurance services

DPIs are part of governments’ GovTech journey to digitize government operations, services, and service delivery, reduce corruption and revenue leakage, and promote participation. They are even seen as enabling low- and middle-income countries to attain the UN Sustainable Development Goals (SDGs), and promote financial inclusion, innovation, and interoperable digital ecosystems. Indeed, asked by the authors to discuss DPIs, even ChatGPT proved to be a true believer, stating that the “development and maintenance of digital public infrastructure are essential for enhancing government transparency, efficiency, and accessibility, as well as promoting economic growth, innovation, and social inclusion within a digital society.”² DPIs have also been discussed as developing countries’ pathway to “digital sovereignty.”

There is still rather limited empirical evidence on the impacts of DPIs – most evidence is based on India’s experience. Studies do indicate that the “India Stack” of identity, payment, and data exchange systems has been transformative in terms of digital inclusion, adoption of digital payments, and public service delivery. Partly as a result, several countries are now leveraging India Stack source code to launch their own DPIs, and the development community is investing in DPIs especially in Africa. The excitement around DPIs has led some countries such as India to explore interoperable models in further spaces, such as in ecommerce.³ Furthermore, India and Brazil are promoting DPI development in other countries.

Yet there are challenges for countries to roll out DPIs and for DPIs to benefit especially MSMEs that seek to engage in crossborder ecommerce:

- Successful DPI adoption and management require significant public sector capacities, connectivity, and an enabling regulatory framework, including data privacy, cybersecurity, and consumer protection. In India where these fundamentals are still under development, DPIs have faced challenges with fraud and data breaches.
- It is not clear whether DPIs subsidized by the government, such as India’s UPI, are sustainable.
- DPIs geared to replacing private providers with essentially a public utility will unlikely promote development outcomes. Governments can also inadvertently create regulatory or business model moats especially around DPI payment systems that limit competition and thereby undermine choice and the availability of value-added services for consumers and micro-, small and medium enterprises (MSMEs).

This paper seeks to promote dialogue on DPs, the fundamentals countries should have in place to adopt, implement, and build on DPs, and the competition policy and business models in promoting digitization and digital services. This paper will:

- Map DP models around the world and create a taxonomy of countries' adoption of DPs, and discuss difference between DPs that displace private providers and DPs that complement and empower them;
- Review findings on the impacts of DPs in delivering outcomes developing countries prioritize, such as financial inclusion, MSMEs' access to credit, cross-border ecommerce; and
- Discuss the regulatory and infrastructure requirements that countries are to have in place to successfully adopt DPs, and create a DP Readiness Index.

This paper concludes that:

- For countries with capabilities to operationalize DPs, DPs can be an important part of the policy mix to promote inclusion and service delivery, and amplify the gains from digitization.
- DPs' development effects will depend to a great extent on the regulatory frameworks and digital infrastructures surrounding them, how DPs are governed, and whether DPs' business model is sustainable over time. Per the DP Readiness Index developed here, most Sub-Saharan African and poorer Asian countries are still far from having the preconditions for successful DP adoption and management.
- DP projects that crowd out private sector solutions undermine user choice and innovation: full competition and level playing fields are essential, both for the DP layer and services built on DPs. There are notable competition policy challenges in countries where the Central Bank both owns and operates a national DP payment system and regulates payment providers.
- More work is needed to ensure that private sector solutions are "built-in" into DPs' technical and business models from the start. A potentially useful model going forward in operating DPs is a consortium model among public and private sector providers.
- DPs can enable MSMEs to advance on their digital journeys and become cashless, but they fall short of promoting crossborder ecommerce. While UPI has been used for crossborder payments in some corridors, MSMEs seeking to engage in crossborder commerce need to rely on the world's leading private payment providers and interbank payments.

Much more research is needed on DPs' impacts, costs, and optimal regulatory frameworks surrounding them. The following section reviews literature on DPs and lays out a taxonomy of models, ranging from the India stack to models led by the private sector, and how the development community is supporting these models. Section three correlates various digital development outcomes with DP models and discusses the pre-conditions developing countries should have in place if seeking to adopt, implement, and build on DPs. Section four concludes.

II. DPIS: WHAT ARE THEY AND WHERE ARE THEY EXPANDING

A. DEFINING DPIS

DPIs are digital tools, platforms, and infrastructure supported by the public sector to facilitate the delivery of public services and enable interactions between citizens, businesses, and the government. DPIs are commonly taken to include one or several of the following components (table 1):

- **Digital identity:** Systems that enable individuals and businesses to establish and authenticate their online identities, to access public services.
- **Digital payments:** Real-time payments systems that enable citizens to transfer money instantly from one bank account to another.
- **Data exchanges:** Data infrastructure that enable the transmission of digital data among citizens and the government.

Here, we also include as DPIs:

- **Corporate registries:** online platforms that provide information on companies' vitals such as address, date of establishment, board of directors, and more; and
- **Open government data:** Platforms that provide access to government-owned data sets and information, typically in a standardized and machine-readable format that enable the development of new applications, analytics, and data-driven policymaking.

B. DIGITAL PUBLIC INFRASTRUCTURE MODELS

DPIs have been likened to the digital economy equivalents of roads, railways, and bridges. They have to a great extent been motivated by governments' desire to promote digital development and inclusion, and promote transactions and economic growth. The world's most famous DPI system is the India Stack, which has the following features:

- **Identity:** Aadhaar, the biometric identification database, provides residents and citizens a 12-digit identity number linked to a photograph, fingerprint and iris scans. A card is issued with these details, which can be linked to a mobile phone. It enables banks, telecom companies and others to verify a new customer's identity and payments to Aadhaar-linked bank accounts. The Aadhaar database is administered by the Unique Identification Authority of India.
- **Payments:** The Unified Payments Interface (UPI) connects Indians' to banks and mobile money apps developed by India's fintechs, enabling small businesses to accept mobile payments for goods and low-cost remittances (case 1).
- **Data:** DigiLocker is a storage for citizen's data, such as Aadhaar card information, driving licenses, vehicle registrations, academic qualifications and medical documents, and certificates and academic records.⁴ In the past, identity could be confirmed by a myriad of physical

documents such as driver's licenses and voter ID cards; now there is essentially one depository of all these data.⁵

Case 1: How does a user onboard and use UPI?

The Unified Payments Interface in India allows users to transfer funds between two bank accounts through a mobile platform for free. It was introduced to promote digital payments and financial inclusion among Indian users, as many Indian people were unbanked and needed a fast and convenient way to send and receive money.

A user might want to start a bank account for various reasons. Access to a bank account would allow individuals to participate in the financial system and build their own financial identity. It is also a way to store any money they have acquired, whether it be through business, the government, work, friends, or family, and enable payments for a variety of other services.

To onboard UPI, a user must have access to a mobile device with Internet connection. After installing and setting up the bank app, users can create their accounts using their UPI ID and mobile number. After their bank account is connected, users can deposit their money and instantly start sending and receiving money to and from other bank accounts.

UPI users initiate payments using a mobile phone number or a virtual payment address, a unique identifier linked to a bank account. UPI also enables users to bank accounts using a UPI-enabled mobile app such as Google Pay, Paytm, Amazon Pay etc. The receiver's financial institution then credits the receiver's account in real-time, settling the payment.

The India Stack is the most famous and encompassing DPI, but great many countries have adopted some elements of DPIs (tables 1-2, figures 1-2, Annex 1). For example, Brazil's Central Bank has recently unfolded two real-time payment models, Pix and SITRAF, Nigeria's Central Bank has promoted the Nigeria Inter-Bank Settlement System (NIBSS) Instant Payment (NIP), and Bank of Thailand has promoted the PromptPay instant payment system and its interoperability with other real-time payment systems in Southeast Asia. The United States has in 2023 rolled out the FedNow real-time payment infrastructure to complement and enhance the existing interbank Automated Clearing House (ACH) payment network.

Numerous governments have pursued digital identity solutions; for example, Singapore pioneered in 2003 with the SingPass that enables citizens to access several services offered by government agencies and businesses online to utilize digital services, prove their identity, and digitally sign documents.⁶ The Philippines has pursued the PhilSys ID that enables Philippine citizens and residents to have access and application for eligibility to social welfare programs and government benefits.⁷ Turkey has put in place the Digital ID for E-Devlet that allows citizens alternative forms of identity authentication to access online public services.⁸ Colombia's Cédula Digital Colombia enables Colombians to verify their identity when traveling to eight other South American countries, acting as a digital ID for contactless cross-border travel in those countries.⁹

Several governments such as Singapore, Netherlands, and Estonia have built national corporate digital ID systems. For example, Singapore's CorpPass that enables businesses to manage their interactions with the government agencies and today is also helping banks meet KYC requirements.¹⁰ The purposes,

scope, and architectures of these systems vary widely, but fundamentally they are designed to enable firms to access multiple government services with a single login and authentication process. Corporate digital IDs also have important immediate value propositions for governments, including facilitating the A&V process for MSMEs seeking government services, improved user experience for MSMEs using government services, and more efficient government processes and workflows.

Some countries have also promoted the data exchange layers that enable open-source data exchange layer solution that enables organizations to exchange information over the Internet. Such a layer was pioneered and branded by Estonia as “X-Road”. It has been implemented in the Faroe Islands, Finland, Iceland, Japan, Kyrgyzstan, Brazil, Mexico, Argentina, Vietnam, and Cambodia; similar models have been used in El Salvador, Namibia, Ukraine, Azerbaijan, and Georgia.¹¹

In addition, many countries have developed open data platforms, via their statistical and other agencies. For example, the EU has the European Data Portal that provides access to open data from EU institutions and member states.¹² Kenya has a Kenya Open Data Initiative (KODI) that makes government data freely available to the public through one online portal.¹³ Several countries have also opened their corporate registries, which is useful for automating KYC and authentication processes. For example, Moldova, Cyprus and UK have all enable freely searchable corporate registries, including with information on company directors and in the case of Moldova, on shareholders.¹⁴

Table I – DPIs’ features and examples

Features	Definition	Examples
Instant payments – deferred settlement	Money exchanges and payment processing that for immediate transfer of funds between bank accounts: Transactions are transmitted, confirmed, and notified to the PSPs involved in close to real time, but the inter-PSP settlement takes place after the payee’s PSP has credited the funds.	<ul style="list-style-type: none"> • PromptPay, Bank of Thailand • NPI, Central Bank of Nigeria • UPI, India • CoDi, Mexico*
Instant payment – real-time gross settlement	Immediate transfer of funds between bank accounts transactions are cleared and settled in real time or close to real time. Settlement of funds is made on an order-by-order basis (that is, on a gross basis).	<ul style="list-style-type: none"> • The Clearing House (TCH), USA • SCT Inst, EU • Pix, Central Bank of Brazil
Digital ID for individuals	An electronic file utilized by computer systems that contains personal identifiable information.	<ul style="list-style-type: none"> • Diia, Ministry for Digital Transformation of Ukraine • E-ID, National Identity Management Commission of Nigeria • SingPass, Government Technology Agency
Digital ID for corporations	Electronic identification that establishes the online presences an authenticity of a corporation or business entity in the digital world, as opposed to a single individual.	<ul style="list-style-type: none"> • E-Residency of Estonia • Dutch eHerkenning • Danish NemID • Residency and M-Residency of Azerbaijan
Data exchange layer	A standardized method for exchanging information between information systems.	<ul style="list-style-type: none"> • X-Road, Information System Authority of Estonia • DigiLocker, Ministry of Electronics and Information Technology/Unique Identification Authority of India • Government Interoperability Exchange (GIX), State Services Commission of New Zealand
Open government data	Information collected, produced, or paid for by public entities that are made freely available to increase access to information.	<ul style="list-style-type: none"> • Mexico, Infraestructura Abierta • Indonesia, data.go.id • Kenya, Kenya Open Data Initiative
Open corporate registries	Publicly accessible databases that provide information about registered corporations or businesses, meant to promote transparency and accountability in the business sector.	<ul style="list-style-type: none"> • Commercial register, Moldova • Companies House, UK • Unified Trade Register, Bulgaria

Figure 1A – Total number of national digital public infrastructure features by region (need to update)

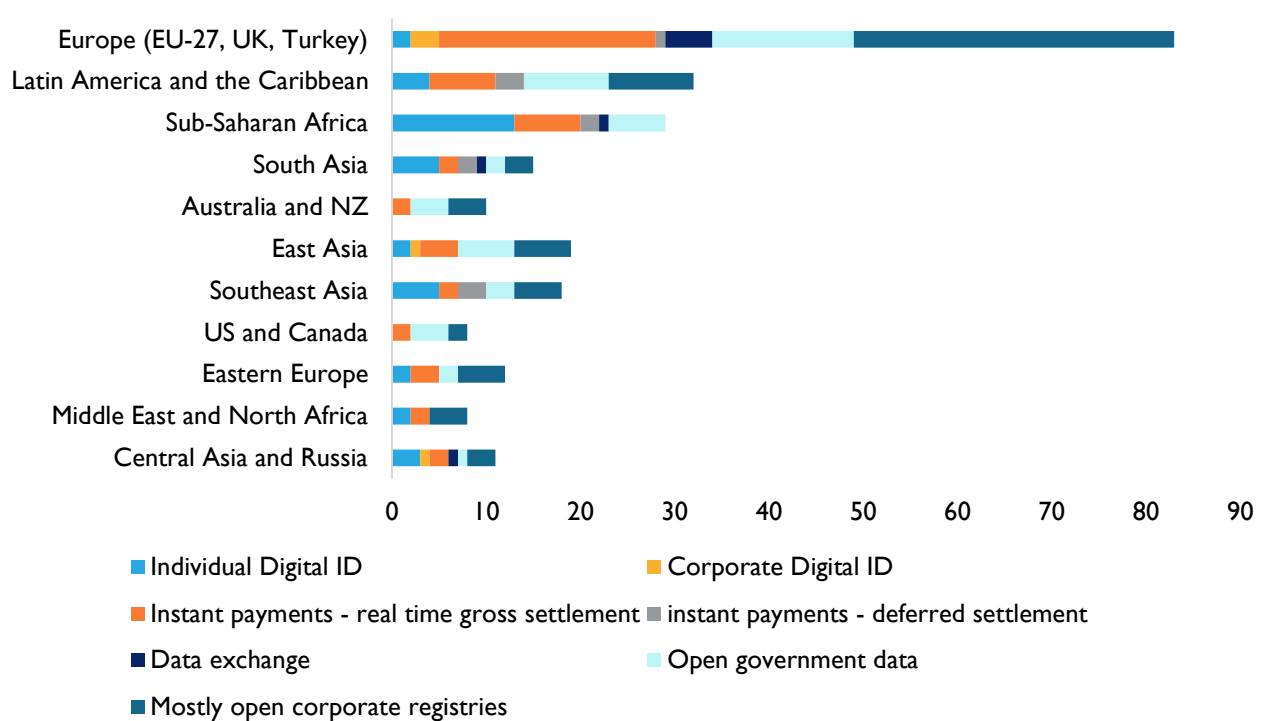


Figure 1B – Average number of national digital public infrastructure features per country in a region (need to update)

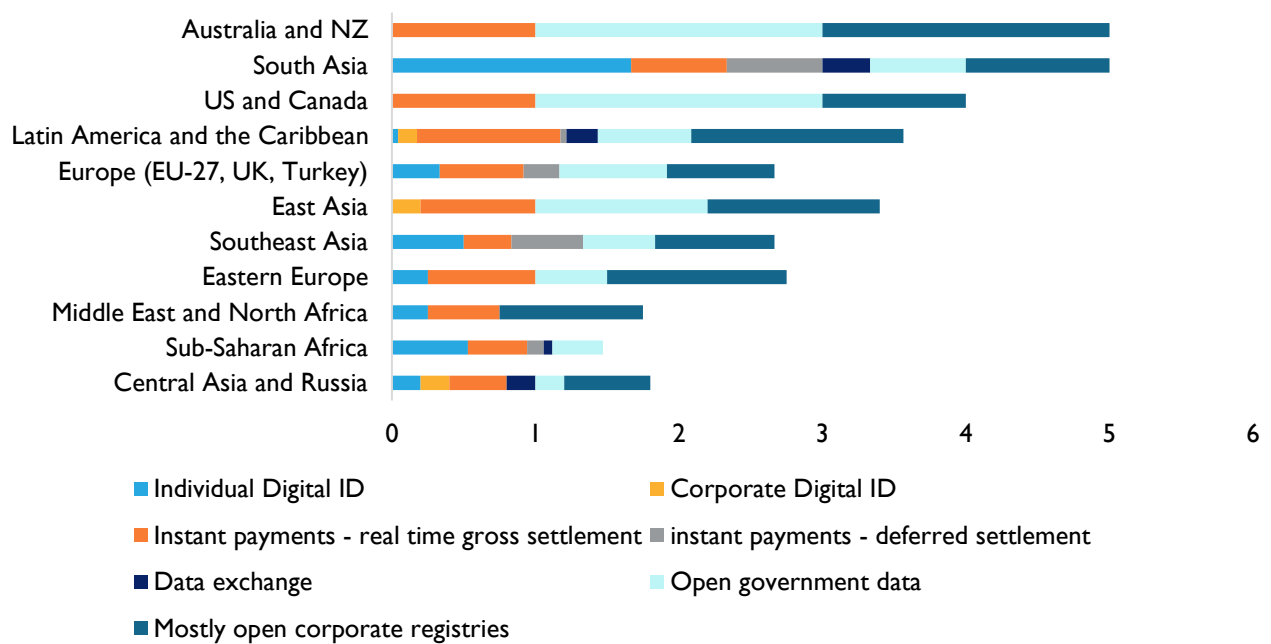
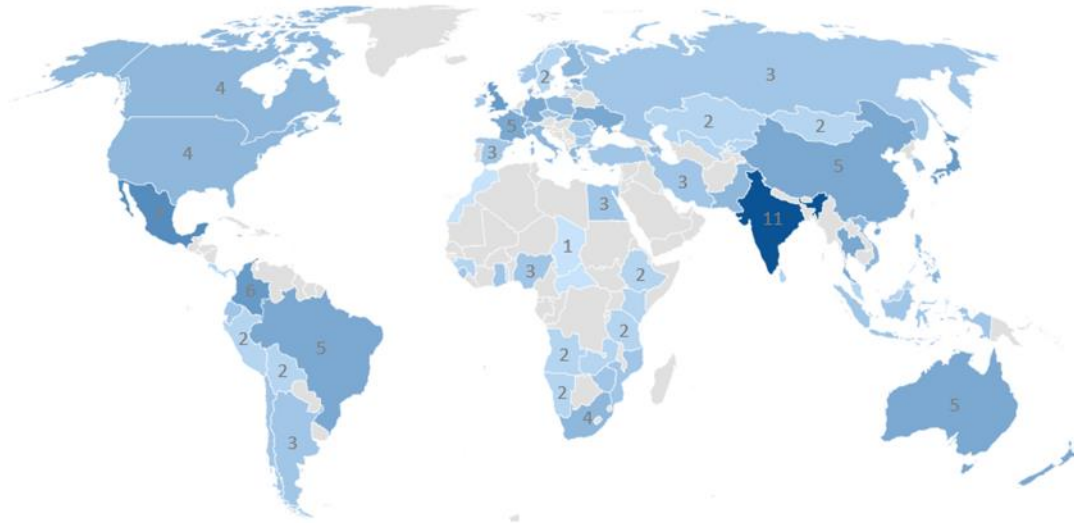


Figure 2 – Digital public infrastructure features in place, by country



Many countries around the world have some types of DPIs in place. However, these solutions vary in their robustness – for example, some countries’ corporate registries are very open and have many machine-readable elements, whereas others have more closed registries and still others do not have open registries at all. In addition, countries have adopted different combinations of DPIs, with Estonia, Singapore and India leading the way with encompassing DPI models to public-private partnership models used for example in the Nordic region and more purely private sector-led models (table 2). And perhaps most fundamentally, in some countries such as India and Brazil, DPI payments are imposed on the private sector and even seek to substitute for private solutions, while in others such as the United States, DPIs are voluntary and seek to enhance private sector solutions.

Table 2 – Types of combinations of DPI features, by adopter country

Type	Examples	Individual Digital ID	Corporate Digital ID	Instant payments	Data exchange	Open government data	Mostly open corporate registries
Superadopters	Singapore, Estonia	√	√	√	√	√	√
	India	√		√	√	√	√
Advanced	Philippines, Thailand, Brazil	√		√		√	
Nordic-style	Finland, Denmark, Norway	√	√	√	√	√	√
Intermediate	El Salvador, Costa Rica, Panama			√		√	
Basic	Sierra Leone, Ecuador	√				√	
	Kyrgyzstan, Togo	√					√
Undigitized	Mauritania, Algeria						

C. BUILDING ON DPIS

DPIs have been enabled by a number of parallel technological developments, such as mass access to devices, expanding Internet connectivity, increasingly sophisticated biometrics, open banking and open finance practices and policies that have socialized service providers into sharing data with each other, and company registries that is increasingly readily available in machine-readable electronic format around the world. In turn, once in place, DPIs are building blocks that enable solutions riding on the ID, payments, and data exchange solutions, such as (table 3):

- **Vaccine records:** Several apps have been built on the India Stack, such as the vaccine registration platform Co-Win.
- **Payment cards:** With the government’s financial backing, India’s card network RuPay has issued more than 600 million cards, most of the debit cards that connect to simple savings accounts opened by the government.¹⁵ India has also created a RuPay payment platform that enables the card holders of the private SBI credit card to make UPI transactions and link their cards to third-party UPI applications.

- **E-invoicing.** The French Chorus Pro e-invoicing platform based on the corporate identity numbers SIREN (9-digit identifier) and SIRET (14-digit identifier that maps company’s location in addition to the SIREN vitals) enables B2G, B2B, and B2C transactions creates efficiencies in tax payments and reduces fraud.
- **Visibility into financial data use:** Singapore’s Financial Data Exchange (SGFINDEX) is built on Singapore’s digital ID SingPass and ensures integrity and user protection by enabling people to access and understand how their financial data is used by government agencies and private service providers.
- **Healthcare services:** DPIs can support the development of digital health records, which in turn can improved the efficiency of healthcare delivery, making it easier for patients to access their medical history and receive appropriate treatment.¹⁶ For example, India’s ABDM serves to connect previously isolated digital health systems by establishing a healthcare ID registry for both healthcare practitioners and facilities. The initiative empowers public and local digital healthcare providers to give patients remote access to precise information and healthcare services. Another example is France’s Health Data Hub that gathers administrative data across different sources and platforms to improve interoperability.

These types of services have been referred to as digital public goods (DPGs) and form part of the broader family of GovTech solutions. There are in addition DPI-like “building blocks” in other domains that enable new use cases. For example:

- **National Urban Innovation Stack (NUIS).** In India, the NUIS provides cities with technology solutions to address urban challenges and helps governments build new solutions.¹⁷ Like the India Stack, NUIS seeks to connect governments and citizens. It also includes the India Urban Data Exchange, an open-source access to cities’ data created in APIs.
- **Digital Product Passport.** The EU is mandating for every product in certain sectors (apparel, electronics) to have a unique ID that records all supply chain activities for that product using interoperable data exchange standards.
- **Kenya Agricultural Observatory Platform (KAOP).** Online platform that gathers data on crop performance, climate patterns, and soil health to help farmers determine productivity. KAOP increases food security, labor productivity, and promotes sustainable agriculture.

Table 3 – Selected services built on DPIS

Name	Country	Enables
e-KYC	Indonesia	All citizens to have a Resident Identification Number to easily transact with government agencies and businesses both online and in-person
Chorus Pro e-invoicing platform	France	B2G, B2B, and B2C transactions creates efficiencies in tax payments and reduces fraud
Open Finance Framework	Philippines	Financial institutions can participate on a voluntary basis in a pilot that will cover public information, subscription and account opening, account information, payment initiatives, and more
OpenCerts Digital academic certificate	Singapore	Bolsters the robustness of education systems and delivers fair practices for employment by enabling accurate, low-cost qualification checks
Singapore Financial Data Exchange (SGFINDEX)	Singapore	Ensures integrity and user protection by enabling people to access and understand how their financial data is used by government agencies and private service providers

D. FUNDING OF DPIS TO DATE

India Stack’s inclusion gains have set a wave of excitement about DPIS and investments in building them. What then are the costs of adopting and maintaining DPIS?

There are various anecdotal estimates. India has been celebrated for spending only \$1 per person to implement and deploy its digital identity system, while Nigeria was in 2017 estimated to require \$4.3 billion on its national digital ID system.^{18,19} India has spent in 2023 nearly \$320 million to promote cards on RuPay and for low-value UPI transactions.²⁰ Some estimates suggests that the \$30 billion are needed to roll out DPIS in low-income nations – \$6 billion to ensure universal ID coverage, and \$2 billion to allow the implementation of real-time retail payment systems, and \$20 billion is needed for digital health programs.²¹

So far, developing countries have used budgetary resources and donor support to launch DPIS. For example, just in 2021-23, development bank loans to DPIS were at least \$1.5 billion, with major investments made in Africa in particular (table 4).

The Co-Develop fund set up among the Rockefeller Foundation, the Norwegian Ministry of Foreign Affairs, and the Digital Public Goods Alliance in 2021 seeks to incentivize experimentation and scaling of DPIS platforms.²² In 2022, global leaders like the UN, USAID, Digital Public Goods Alliance, Bill and Melinda Gates Foundation, and more made a commitment to implement and fund DPIS through the Digital Public Goods Charter and a \$295 million pledge – the Gates Foundation committed \$200 million over the next five years and the governments of Norway and Germany that committed \$50 million and \$35 million, respectively.

Table 4 – Examples of donor funding of DPIS

Country	Funder	Year	Instrument and amount	Use of proceeds
Indonesia	World Bank	2023	Loan, \$250m	Improve population and civil registration systems and develop key digital public infrastructure: an identity verification and e-KYC platform, a digital identification app, and a data exchange platform ²³
Honduras	World Bank	2023	Loan, \$40m	Strengthen National Identification Ecosystem
Sierra Leone	World Bank	2023	Loan, \$12m	Facilitate interoperability of card transactions among channels and payment service providers ²⁴
Uganda	World Bank	2023	Loan \$200m	GovNet, Expanding the digital infrastructure outreach Enabling Digital Transformation of the government ²⁵
Côte d'Ivoire and Guinea	World Bank	2023	Loan, \$122m	Increase the number of persons Côte d'Ivoire and Guinea who have government-recognized proof of ID
Chile	IDB	2023	Loan, \$100m	Design and implement digital services with a citizen focus, the adoption of technologies for the digital transformation of the State ²⁶
Panama	IDB	2022	Loan, \$60m	Government procedures and services more efficient, enhance cybersecurity, protect and manage data, and cut costs in interactions with government agencies ²⁷
Tanzania, Uganda	Gates Foundation, Coil, Google, ModusBox, Rockefeller Foundation	2017-20		Open-source platforms for real-time payments
Gabon	World Bank	2022	Loan, \$68.5m	Digital Gabon Project, modernizing legal ID systems ²⁸
Togo	World Bank	2021	Loan, \$30m	The financing provided to the West Africa Regional Communications Infrastructure Program will enhance the impact of significant projects in Togo, aiming to expand geographical reach of broadband networks and make communications services more affordable. ²⁹
Morocco	World Bank	2021	Loan, \$450m	Increase public access to financial and digital services for individuals and businesses ³⁰
Nigeria	World Bank	2019	Loan, \$433	Expand the digital ID ecosystem ³¹

Peru	IDB	2022	Loan, \$50m	Improve information technology infrastructure to provide public access to information to promote citizen transparency, participation, and accountability ³²
Belize	IDB	2022	Loan, \$10m	Help digitize government services related to MSMEs and reduce transaction costs for MSME; optimize and digitalize government processes related to citizen registration services ³³
Brazil	IDB	2022	Loan, \$164m	Expand digital inclusion through greater access to and use of digital public services ³⁴
Malawi	AFDB	2022	Grant, \$14.2m	Create a more efficient and transparent digital payment system ³⁵

III. FUNDAMENTAL DIFFERENCES AMONG DPIS: THE ROLE OF THE PRIVATE SECTOR

While many countries have adopted DPIS, there are some very fundamental differences among them, especially when it comes to the respective roles of the public and private sectors. A good case in point is a contrast between India's UPI and Brazil's Pix on the one hand and America's FedNow, on the other. While the UPI is in essence a public utility that all banks must adopt and offer for free, FedNow is a voluntary platform for banks, geared to enhancing banks' services to their customers. The role of the private sector in DPIS is still debated very little, yet it is highly consequential to the future of digital economies and development. Is countries' digital infrastructure led by the public sector and private sector? Which promotes inclusion, innovation, cybersecurity, access to finance, and other desirables? Could public and private sectors be complementary rather than substitutes? The following discusses examples of different ways in which public and private sectors play a role in payments, authentication, and ecommerce.

A. PAYMENTS

While several governments have enabled fast payments, there are fundamental differences in these models when it comes to the role of the private sector. A good example is the contrast between India's UPI and the new U.S. real-time payment system FedNow launched in 2023.

UPI is motivated by interest in financial inclusion and mandatory for banks. It has implied a loss to mobile app providers, payment service providers, and banks' income stream – and implied new costs for them in the forms of connectivity to UPI, security controls, compliance costs, and the settlement costs (as the settlement between the sending and receiving banks is not immediate). It is also worried to impede incentives for further payments innovation.³⁶

Unlike UPI that is offered to individuals through a mobile app, FedNow is available to banks and not their customers via apps (like Venmo and Zelle that are provided by the private sector for C2C payments).³⁷ FedNow is created and managed by the U.S. central bank, the Federal Reserve, to enable instant payments and transfers 24/7 between bank accounts held by individuals and businesses. FedNow's value proposition is that the payment appears instantly on the account when made. The alternative - the Automated Clearing House (ACH) – is also cheap, flexible, and reversible, costing \$0.20-\$1.50 per transaction. ACH can be pushed (whereby the payer initiates the transaction) or pulled (payee withdraws the payment). However, ACH is also slow – payments settle in only 2-5 business days. In contrast, in the FedNow system, the TCH is a hub handling the clearing between banks. Banks pre-fund their accounts and TCH updates the participants' TCH ledger accounts in real-time.³⁸

FedNow is voluntary for banks and equip banks with a new value adding service and tools to identify and combat fraud attempts, such as flag suspicious accounts and limit the amount and frequency of payments by those accounts.³⁹ JP Morgan, Wells Fargo, and 35 other major banks opted in to use FedNow as of July 2023. FedNow does not affect credit card providers – while the Brazil's central bank has envisioned the Pix system as replacing credit cards.

FedNow is one of many bank-to-bank fast payment systems around the world. Some others include Europe's TARGET Instant Payment Settlement (TIPS) launched by the European Central Bank (ECB) in November 2018. It build on the pan-European system based on the SEPA Instant Credit Transfer (SCT Inst) scheme enables payment service providers to offer instant fund transfers around the clock.⁴⁰ In

Singapore, the Fast and Secure Transfers (FAST) system that launched in 2014 enables customers of participating financial institutions to complete near real-time electronic funds transfers 24/7. The UK's Faster Payment System and Australia's New Payments Platform offer similar benefits.

While UPI users initiate payments using a mobile phone number or a virtual payment address, a unique identifier linked to a bank account, FedNow users use the recipient's bank account number and routing number.

In terms of adoption, UPI has massive adoption at 2.5 billion; FedNow is just starting and has numerous alternatives. Indeed, UPI, Pix and other RTP rails are much like public utilities to achieve objectives like financial inclusion and demonetization. FedNow in contrast is a modern version of the ACH system that provides new value to market participants. As such, UPI has had now cost through March 2023, while FedNow charges for the convenience – a monthly fee of \$25 per routing transit number, a \$0.045 fee per credit transfer, and a \$0.01 fee per request for payment message. UPI has transaction limits depending on the bank and type of account, typically from tens of dollars to a few thousand dollars, while FedNow has a default transaction limit of \$100,000.

Which systems then is superior in the longer-run? From the perspective of banks, FedNow is a value-adding service to banks that can generate more revenue and does not displace private sector providers, while UPI is imposed on the market. UPI is created to promote demonetization and financial inclusion, but it is not clear that it can be sustainable without charging users.

B. AUTHENTICATION

Another area where the private and public sectors play important roles is authentication. A growing number of countries have adopted, or are adopting, individual digital IDs that enable citizens and residents to access public and private services efficiently; the United Nations has highlighted “legal identity for all” as a key 2030 Sustainable Development Goal. A set of countries such as Singapore, Estonia, Azerbaijan, and Netherlands have also already adopted a corporate digital IDs which firm representatives can use to access and use numerous government services, and, increasingly, private B2B services.

There are of course also private sector authentication methods. Many smartphone apps now have an option for biometric authentication through facial, fingerprint, or voice recognition. Users are able to use their biometrics to gain access to their device or certain apps that hold personal information. Another common method of authentication is Two-Factor Authentication (2FA) and Multi-Factor Authentication (MFA). Users can receive SMS or email codes to enter for login verification. There are also time-based one-time passwords that are time-sensitive codes used in authenticator apps. Another option for additional factor authentication is through push notifications. When a user is trying to access an app, a notification is received on a mobile device for approval or denial of access. A less secure way to protect an account is through knowledge-based authentication whereby security questions are asked and users answer personal questions or provide personal information like birthdates or social security numbers as a form of identity verification.

In between these extremes are the Nordic bank ID models, established by banks years ago. For example, in Norway, an electronic identification using BankID meets the official requirements applying to identity verification and electronic signatures. The Finnish government accepted the market's chosen bank ID system in 2009 and it has been used for accessing government services since then. Sweden's BankID was born of a process where banks and the government worked together; the parties even joined forces in inviting tenders for technology upgrades.⁴¹ The systems can be used for transactions that

would normally require paper-based proof of ID, such as car loans, mortgage applications, and public sector interactions.

A critical component is still missing from national IDs: crossborder interoperability. A collaborative ID project will be very unlikely – even the EU’s effort to connect national digital ID systems has stalled. An internationally interoperable ID would likely have to come from the private sector and ideally consist of self-managed identities enabling businesses’ customers, B2B marketplaces, and financial, logistics, insurance, and other service providers to authenticate businesses quickly and extract their key corporate vitals, based on government data, publicly available data, and privately apportioned data. Such a self-sovereign ID system would be far more scalable and cost-effective than countries building their own gold-standard IDs and then seeking to harmonize and merge them.

C. SOLUTIONS BUILT ON DPIS

There are also variations in the participation of the private sector in solutions built on DPIS. In many instances governments have built such solutions on DPIS as card networks (RuPay in India), e-invoicing (Chorus in France), and financial data exchange (SGFINDEX in Singapore). There are also private sector solutions leveraging DPIS. For example, in India, software startup Setu enables programming interfaces for financial products riding on Aadhar and DigiLocker and a sandbox where developers can test their applications, and the Walmart-owned PhonePe app enables users to use UPI, debit and credit cards, or e-wallet to recharge phones, pay utility bills, and make instant online and offline payments. The SGFINDEX has enabled the DBS bank to build the DBS NAV Planner to offer financial and retirement planning solutions to Singaporean residents.⁴²

These types of models are positive as far as they enable the private sector to provide innovative solutions, and ensure competition in the development and provision of various services. However, forcing private sector actors that build on DPIS to share proprietary data with the government is not conducive to innovation and investment. DPIS should also not limit competition or undermine private providers of two-sided platforms and services providers – such as ecommerce, financing, and logistics platforms.

IV. WHAT ARE THE IMPACTS OF DPIS ON ECONOMIES AND MSMES?

There is to date limited knowledge on the impacts of the types of DPI models employed by India and Brazil, for example, that have forced the private sector to adopt a new payment system. Most studies have been focused on the India Stack; there are some anecdotes from DPIS from around the world. The following reviews various benefits and challenges of DPIS.

A. GAINS FROM DPIS: INCLUSION, EFFICIENCY, ACCESS TO SERVICES

Research indicates that DPIS have generated striking gains in terms of digital and financial inclusion and efficiency of service delivery (table 5):

- **Cost savings from identity verification.** Research suggest that a digital ID card dramatically lowers the cost of confirming people's identities, with open-access software standards facilitating digital payments between banks, Fintech firms, and digital wallets.⁴³ For example, in India, the costs of customer identity verification using Aadhar is only Rs5, compared to prior setting where the cost rose to Rs1,000 (approximately \$12). This in turn helped Indian banks open over 450 million new accounts over the past decade.⁴⁴ In Jamaica, the NIDS digital identity has helped reduce the need for Jamaican citizens to register for each governmental benefit program.⁴⁵
- **Low cost of services.** India's UPI has been offered at zero cost through May 2023. The Brazilian Central Bank estimates the cost of Pix at 0.22 percent of a transaction's value for merchants (market sets the rate merchants should pay), whereas debit card payments in Brazil cost slightly above 1 percent and credit cards 2.2 percent.⁴⁶ The low cost has facilitated uptake. In India, digital payments increased three-fold in volume and by 50 percent in value between June 2020 and June 2022.⁴⁷ In Brazil, just 15 months after its launch, Pix had been used by two-thirds of Brazilians and risen to rival card payment volumes. Granted, for countries where new digital payment systems replace cash, there are further gains from the end of manual processing of cash or cheques
- **Access to public services.** DPIS have helped governments deliver public services at scale. For instance, Thailand's PromptPay, a real-time payment system, allows people and businesses to link a financial account with their ID or phone number, which has helped the government to roll out cash assistance during COVID-19. According to the World Bank, the countries that were able to use digital databases and data exchange platforms reached, on average, 51 percent of their population with cash transfers during COVID-19, whereas countries that could not rely on existing databases to cross-reference eligibility reached only 16 percent.⁴⁸ Ukraine has included in its digital government application (DIIA) a digital wallet where citizens can store digital documents, such as a passport recognized by neighboring Moldova and Poland, and continue using public services and receive emergency payments. The DIIA app also allows users to donate money or seek compensation for damaged property during the invasion.⁴⁹
- **Accountability and reduced corruption and improved tax collection.** Digitization has been found to improve the efficiency of revenue collection and reduce revenue leakage. In India, Aadhaar identification has also helped prevent fraud in public benefits, such as so-called double-dipping (claiming a benefit several times) and cut costly intermediaries. The Goods and Services

Tax Network has improved transparency due to open APIs and reduced corruption at the local level.⁵⁰

These improvements can translate into macroeconomic gains. The UNDP estimates DPIs could, thanks to greater inclusion and reduced leakage, result in 1-1.4 percentage point growth in developing nations.⁵¹ The Gates Foundation argues that DPIs can benefit between 16 to 19 million micro and small enterprises by giving them an equal opportunity to reach new customers and markets.⁵²

Table 5 – Gains from DPIs

Country	System	Benefit
India	Aadhaar identity platform	<ul style="list-style-type: none"> Reduced fraud and corruption by providing identification to more than 1 billion Indians.⁵³
India	Aadhaar Enabled Payment System	<ul style="list-style-type: none"> Increased financial inclusion for underserved communities in India.⁵⁴
Brazil	Pix real-time payments	<ul style="list-style-type: none"> Cheaper than debit/credit cards and more convenient than cash, so it provides an incentive for the unbanked population to open bank accounts to engage in financial transactions.⁵⁵ Levels playing field between large and small banks.⁵⁶
Jamaica	NIDS	<ul style="list-style-type: none"> Reduces need for Jamaican citizens to register for each governmental benefit program.⁵⁷ Minimizes identity theft.⁵⁸
Various EU Nations	SCT Inst. Payments	<ul style="list-style-type: none"> Allows for domestic and cross-border payments in euro to be made to and received from participating PSPs anywhere within the Single Euro Payments Area.⁵⁹
Philippines	PhilSys ID	<ul style="list-style-type: none"> Simplifies public and private transactions, reduces corruption, strengthens financial inclusion, and promotes ease of doing business.⁶⁰
Ukraine	Diia Digital ID	<ul style="list-style-type: none"> Used to broadcast the location of Russian soldiers within Ukraine and allows users to donate money or seek compensation for damaged property during the invasion.⁶¹

B. CHALLENGES WITH DPI IMPLEMENTATION AND MANAGEMENT

At the same time, there are also various challenges associated with DPIs' rollout and management. For example:

- IT capability and infrastructure.** Just as private solutions, DPIs need to be designed and implemented to benefit rural regions that may not have the same internet and broadband connections as do urban centers. In Indonesia, a third of the population does not have access to the Internet – a gap that needs to be bridged for the population to benefit from the digital ID

promoted by a \$250 million loan from the World Bank.¹ Nonetheless, the connectivity challenge is still vast – the IMF has argued that “in many developing countries, IT systems related to public finance have structural weaknesses that could hamper the adoption of innovative digital solutions.”⁶²

- **Access to devices – feature phones, smartphones.** The adoption of devices has exploded around the world, but mobile phones and smartphones are still beyond the reach of hundreds of millions. According to the Global System for Mobile Communications Association, (GSMA), about 43 percent of Africa’s population, or 630 million people in Africa and percent of the Asia-Pacific population, or about 985 million people have no devices.⁶³ While biometrics enable deviceless individuals use UPI in India, access to the full functionality of India Stack does require access to a smartphone or at least feature phones. The full functionality of UPI also requires users to have a bank account, as it facilitates transfers between these accounts. According to the Center for Internet and Digital Economy, about 22 percent of Indians over the age of 15 do not have bank accounts.⁶⁴
- **User uptake and understanding.** DPLs require ongoing citizen engagement for their design, implementation, and evaluation, and ensuring populations with limited digital literacy can use them and solutions built on them. There have also been considerable challenges in ensuring that DPLs are designed in a citizen-centric way and take up and used properly. For example, in Panama, the design of Vale Digital, an electronic payment distribution platform meant to expedite welfare payments, resulted in a low renewal rate, but also affected access to crucial resources in times of crisis. Mexico’s instant payment system CoDi has also had significant challenges with user awareness and adoption (case 2). There are also challenges related to transmitting information related to DPLs. For example, Aadhar users have feared misuse of their information yet lack information on the precautionary measures that can be taken to mitigate misuse.⁶⁵

Case 2: Adoptions successes and failures: Pix vs CoDi

In November 2020, Brazil’s Central Bank introduced Pix, which has garnered adoption by over 700 financial institutions and is accessible to over 120 million users.⁶⁶ Mexico’s electronic payment platform Cobro Digital (CoDi) was announced in 2018 and officially launched in September 2019. Even though it was launched earlier than Pix, CoDi has only amassed 14 million users as of May 2022.⁶⁷ Brazil’s adoption of its instant payment system, Pix, has been significantly more successful than Mexico’s adoption of CoDi due to a variety of factors.

Brazil’s success with Pix can be partially attributed to its collaborative development approach. The Central Bank of Brazil worked in partnership with financial institutions, fintech companies, and stakeholders to create Pix’s comprehensive and user-friendly system. Mexico’s CoDi did not have the same collaborative environment and was spearheaded primarily by the central bank. CoDi was not created through collaboration with key industry players and was in some ways misaligned with the market’s needs. Another driver behind Pix’s success is its seamless integration into Brazil’s existing infrastructure. Pix allows users to link their bank accounts to their mobile phone numbers or email addresses and this has made it easier for people to use Pix for different financial transactions.

¹ One solution may come from the private sector; Starlink is as of June 2023 bringing satellite internet to underserved parts of Indonesia.

Alternatively, CoDi had a harder time integrating because there was limited initial participation from banks.

Pix was created with the intention of inclusivity. It allowed residents to create their digital wallets without a traditional bank account. Those who were unbanked still had access to Pix. While CoDi was still accessible, it mainly focused on individuals who were banked, limited its reach. Trust within an institution is difficult to come by. Brazil's government and participating financial institutions produced comprehensive marketing campaigns to promote the system. They emphasized its convenience in security, and eventually started to build trust among users.

In contrast, CoDi had difficulty creating awareness and trust among users due to a lack of coordinated marketing efforts. Finally, Brazil had a more favorable regulatory framework that helped Pix thrive. There were well-defined rules and standards that ensured interoperability and security. In Mexico, CoDi had to address issues related to fraud and security, slowing its rate of adoption.

- **Cybersecurity.** While the world's largest private payment networks excel at securing digital transactions globally, DPIs in place today have had a less consistent record. For example, India's Aadhaar has experienced numerous cybersecurity and data privacy challenges; in 2018, some 200 official government websites accidentally made personal Aadhaar data public, leaving hundreds of billions of people open to identity theft.⁶⁸ Cybersecurity is in general a challenge for public sector around the world; just in the past few years, countries such as Australia, Peru, and Costa Rica have suffered a devastating cyberattacks on their government agencies.
- **Fraud.** The Aadhaar-enabled Payment System (AePS) enables Aadhaar-linked account holder to withdraw money from it anywhere in India through biometric authentication with a business correspondent (BC), an individual agent carrying a "micro-ATM".⁶⁹ There have been reports of abuses and extortion, such as BCs' forcing defenseless or elderly people to put their finger in a point-of-sale machine and transfer funds. There have also surfaced AePS scams like a "scholarship scam".
- **Concerns about government accountability and overreach.** DPIs and solutions like SGFINDEX built on them in principle make information more easily accessible to citizens, and enable people to keep public officials more accountable. However, as DPIs bring together millions of records, there are concerns about citizen's data privacy and the rise of "surveillance state." For example, since digital IDs are centralized rather than decentralized, citizens are to trust the government to protect their data from misuse, both by bad actors and the state itself. This challenge can be exacerbated by concerns that governments use digital IDs for AI programs, for example for law enforcement as done in India, potentially resulting in.⁷⁰
- **Competition and accountability.** To the extent that DPIs and solutions built on them are government run and crowd out the private sector either through regulation or business model design, they limit competition and choice for consumers and incentives to innovate. There are broader competition policy concerns in cases like Brazil's where the Central Bank both operates the Pix payment system and regulates payment systems. So far it is not clear how competition policy authorities might address these types of conflicts of interest.
- **Sustainability.** DPIs' sustainability is not clear.⁷¹ For example, in India, NPCI is a not-for-profit organization that has offered UPI payments at no cost, to promote inclusion and

demonetization. In addition, the Indian government also incentivizes banks to provide payment services at low cost – the Ministry of Finance pays a subsidy to banks for foregone fees. In fiscal year 2023-24, India’s budget for promoting digital payments (including other initiatives) is US\$188 million. The G20 too has raised concerns about the sustainability of DPs, noting that the ecosystem at large would be undermined if entities that manage DPs, were to become financially unsustainable.⁷² Granted, it can be imagined that the economic gains from increased adoption and financial inclusion should more than make up for the costs of maintaining DPs. However, governments do face the challenge of launching and maintaining DPs – and appear to be coming face to face with it. For example, in India, UPI transactions of over 2,000 rupee (about US\$24.20) that are not made directly from bank account to bank account have since April 2023 had a 1.1 percent fee on the merchant receiving the payment. The fee applies specifically in cases where the customer has a wallet of a particular company and makes a payment to a merchant with a wallet of another company.⁷³

- **Crossborder interoperability.** Cross-border interoperability would ideally be built into DP models at the design stage. Yet so far DPs’ cross-border interoperability appears to be an afterthought even in advanced economies that have implemented DPs. There are however a number of efforts to promote interoperability among national DPs indirectly (such as India and Brazil providing their DP source code to other countries, case 3), and directly, where countries have integrated their payments networks. For example, India has recently connected Indians living in Singapore, UK, Australia, Canada and the United States to UPI in order to allow instant cross-border remittances.⁷⁴ The Reserve Bank of India has also sought to expand the reach of RuPay in the South Asian market.⁷⁵ There are also numerous RTP interoperability efforts especially in Southeast Asia where numerous countries have adopted RTPs.⁷⁶ While transactions have grown in these (typically bilaterally) interoperable networks, the setting is far from the global interoperability of the leading card companies. Similar challenges have, because of divergent national regulations and customer due diligence requirements, faced the European Union’s eIDAS effort to promote interoperability among EU Member States’ digital ID systems.
- **Interoperability with global card networks.** Private card solutions enable individuals and businesses transact across global markets. Yet it is not clear they can easily interoperate and build on solutions such as UPI and Pix – there are regulatory, technological, and business model challenges to address. For example, it is not clear that the private sector can compete on a level playing field in providing solutions. For example, the Brazilian Central Bank has openly discussed Pix as a substitute to cards, and, in a further complication, owns the Pix payment system while regulating the payment market. There are also concerns around data sharing – for example, if private providers’ data travels in public sector-managed payment networks, the government still essentially controls the market.

Case 3: India and Brazil work to promote DP interoperability

In 2022, India’s Prime Minister Narendra Modi announced that India will offer its source code to the Global Public Digital Goods repository. With this announcement, other nations will have access to India’s Aadhaar identity service, DigiLocker cloud storage, and more.

The purpose of opening up the India Stack source code to other nations has positioned India to become a leader in developing digital transformation projects and can be of help to other countries who wish to do the same through technology solutions.

Countries that choose to adopt these technologies have the option to customize the parts of the DPI they want, so they can intuitively build their own systems that are interoperable. Indian organizations like the International Institute of Information Technology launched the Modular Open Source Identity Platform (MOSIP) in 2018 to offer a version of Aadhaar to other countries. The Philippines and Morocco have begun using the technology while others like Ethiopia, Guinea, Sierra Leone, Sri Lanka, and Togo have begun piloting it.⁷⁷

Brazil's Central Bank revealed that it would release the source code to Pix, their instant payment platform, to other countries for free. As of recently, Colombia, Uruguay, and Peru have expressed interest in implementing systems similar to Pix. If these countries implement Pix into their payment systems, it could increase the efficiency between banks whenever users want to transfer money across borders. Fintech company Fiserv was able to export Pix overseas by allowing its merchants in Argentina to start taking payments through Pix. Now, Brazilian tourists in Argentina can easily pay with Pix, instead of going through any payment hurdles that come with cross-border travel. and directly.

The indirect way is sharing source code. For example, India has provided India stack source code to Morocco, Philippines, which have started to use it, and Sierra Leone, Kenya Ethiopia, Nigeria, Sri Lanka, and Samoa that have yet to put it into use. For its part, Brazil has provided Pix source code to Uruguay, Colombia, and Peru.

C. DO DPIS SUPPORT MSME CROSSBORDER ECOMMERCE?

Policymakers around the world have highlighted MSME digitization and ecommerce as pathways to job-creation. Do DPIS help or hinder these aims?

One potential answer is that DPIS enable digital inclusion for MSME that are starting their ecommerce journeys and can thus accelerate MSMEs' adoption of ecommerce and path to further international payment systems. In addition, DPIS enable demonetization that promotes efficiencies in and digitization of MSMEs' payments acceptance, and could also enable businesses to transact with previously cash-carrying customers. In these scenarios, DPIS can complement private sector payment providers and expand the total addressable market.

DPIS may also however hinder MSME ecommerce if they lock MSMEs into a certain system and limit choice and/or undermine innovation and investment in new solutions. DPIS also have limited crossborder interoperability – to be able to transact across borders and across countries, MSMEs just about need global card providers, Fintechs such as Airwallex and Rapyd that enable crossborder payments typically in partnership with card companies, and/or the interbank Swift payments.

The jury is still out on DPIS effects on MSME ecommerce – and the effects of different types of DPIS on MSMEs. One way to start answering the impact on MSMEs engaging in ecommerce is to ask MSMEs' on their DPI use and views. A subsequent study aims to carry out this type of survey.

V. DPI READINESS: INFRASTRUCTURE, REGULATIONS, AND PRIVATE SECTOR ROLE TO MAKE DPIS WORK

For DPIS to be sustainable, as well as ensure inclusion, secure users' privacy, cybersecurity, rights, ideally countries that adopt them would have a number of preconditions in place, such as wide-spread internet connectivity and data privacy and cybersecurity laws. In addition, regulatory frameworks surrounding DPIS need to encourage level playing fields and full competition among public and various private solutions.

A. DPI READINESS INDEX

What then is developing countries' readiness for adopting and managing DPIS? We explore this question through a pioneering DPI Readiness Index consisting of the following variables:

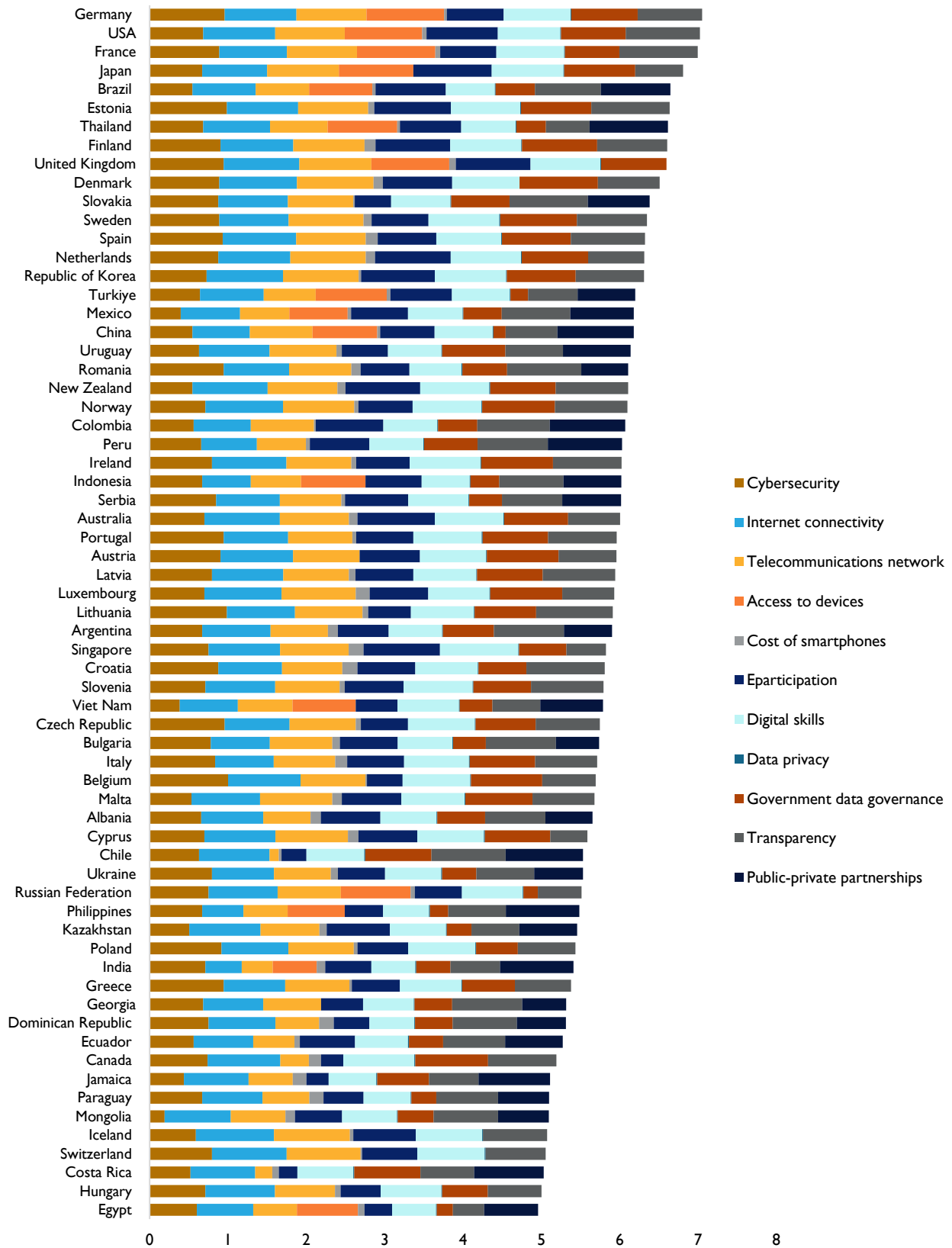
- **Privacy regulations:** We leverage our mapping of data privacy rules around the world. Countries with complete legislation are scored as 1, countries that do not have a data privacy law are scored as 0.⁷⁸
- **Cybersecurity capabilities:** DPIS should and do include cybersecurity technologies and measures to safeguard sensitive information, protect against cyber threats, and ensure data privacy. Estonia's National Cybersecurity Index provide multiple data points on the characteristics of cybersecurity readiness for 2021, which also correlate heavily with legal frameworks for cybersecurity.
- **Connectivity:** Provision of high-speed internet through broadband, for example through fiber-optic cables, wireless towers, and satellite systems and a telecom infrastructure facilitate the uptake of DPIS. We use here data from the United Nations on internet connectivity through the Online Service Index in 2022, and from the UN on Telecommunications Infrastructure Index in 2022. The Online Service Index measures a country's level of sophistication in online presence. The Telecommunication Infrastructure Index is a weighted average of six primary infrastructure-related indicators that define a country's ICT infrastructure capacity.⁷⁹
- **Access to devices:** Access to devices, most fundamentally phones and smartphones, is key to full benefits from DPIS. Access is here proxied with data from Newzoo in 2019 on smartphone users.⁸⁰
- **Cost of devices:** Cost of devices also shapes access; we use here smartphone and feature phone cost data for 2022 from the Alliance for Affordable Internet.⁸¹
- **Digital skills and literacy:** Promoting digital skills and literacy is necessary to enable citizens to effectively use digital services. Digital literacy is here proxied by the World Bank's Human Capital Index from 2020.⁸²
- **Government data governance.** Data governance frameworks to ensure the security, privacy, and ethical use of data. This was found through the World Justice Project's Rule of Law

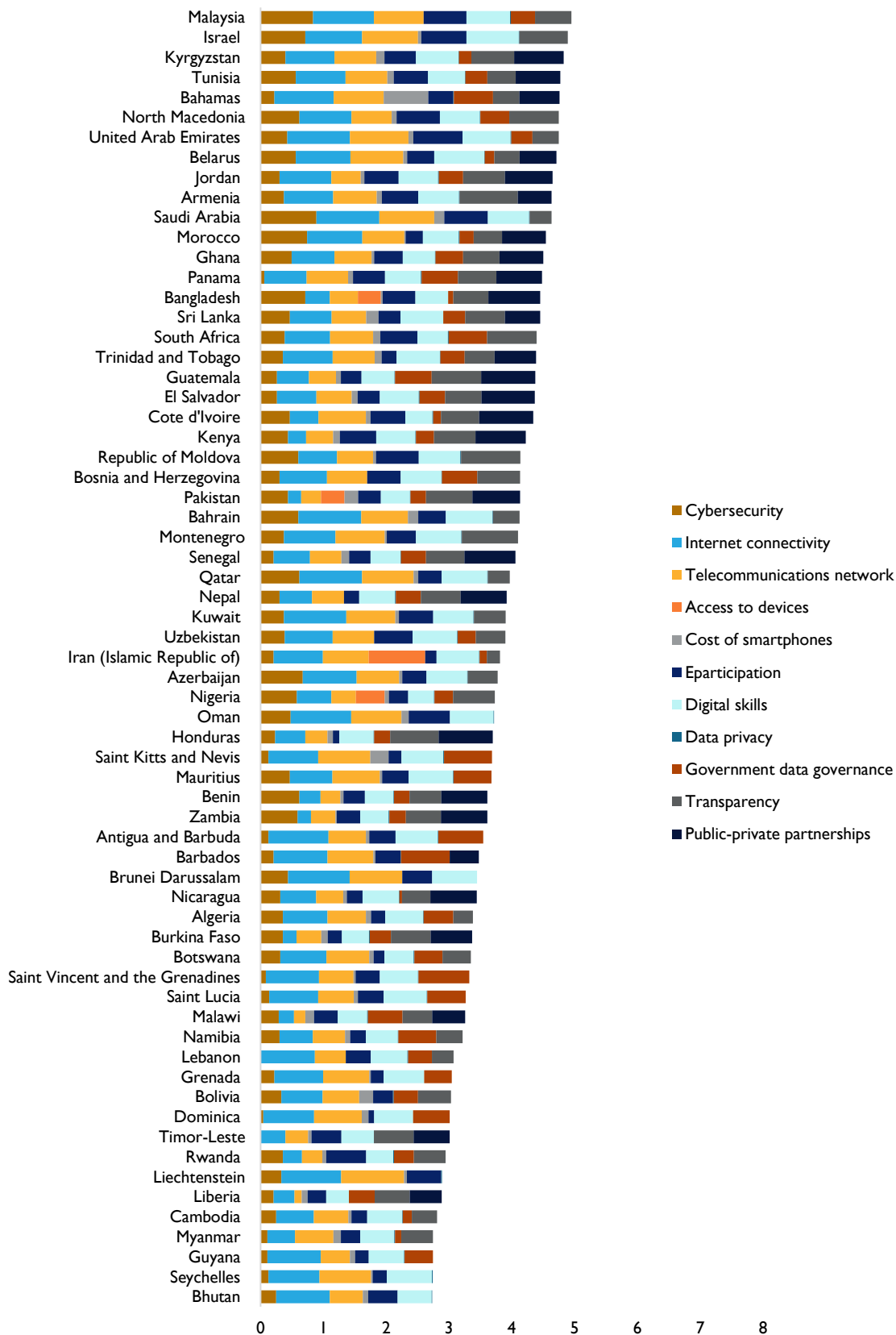
Index. Factor 4 covers fundamental rights, and government data governance was found through right 4.6: Freedom from arbitrary interference with privacy is effectively guaranteed, where police or government officials conduct physical searches without warrants or intercept electronic communications of private individuals without judicial authorization.⁸³

- **Public-private partnerships:** Readiness to develop public-private partnership should aide economies in creating DPIs that promote rather than crowding out DPIs. We use here as a proxy for public-private partnership readiness by the Infrascopes Index Ranking that measures the enabling environment for public-private partnerships in infrastructure development and consists of five components: enabling laws and regulations, the institutional framework, operation maturity, investment and business climate, and financing facilities for infrastructure projects..⁸⁴
- **E-participation:** Measures the use of information and communication technologies (ICTs) that allow citizens to participation in government-related processes. The E-participation Index is supplementary to the United Nations E-Government Survey and acts as a framework composed of three core components: e-information, e-consultation, and e-decision-making.⁸⁵

In our analysis of over 190 countries on these dimensions, there are significant variations in DPI readiness – OECD nations and Singapore have high levels of readiness; India is in the second quartile at 77 percent from the global frontier economies, Germany and the United States; and the best-performing sub-Saharan African nation, Ghana, is at only 64 percent from the global frontier (figure 3) Most other sub-Saharan African countries trail far behind at 50 percent from the global frontier or lower and have still very limited DPI adoption rates (table 6). Brazil is the top-10 with countries like France, Finland, and Japan. Colombia, Mexico and Thailand do well of emerging economies in the top quartile of economies. Countries with very limited adoption capabilities include Libya, the DPRK, Eritrea, and South Sudan.

Figure 3 – DPI Readiness Index





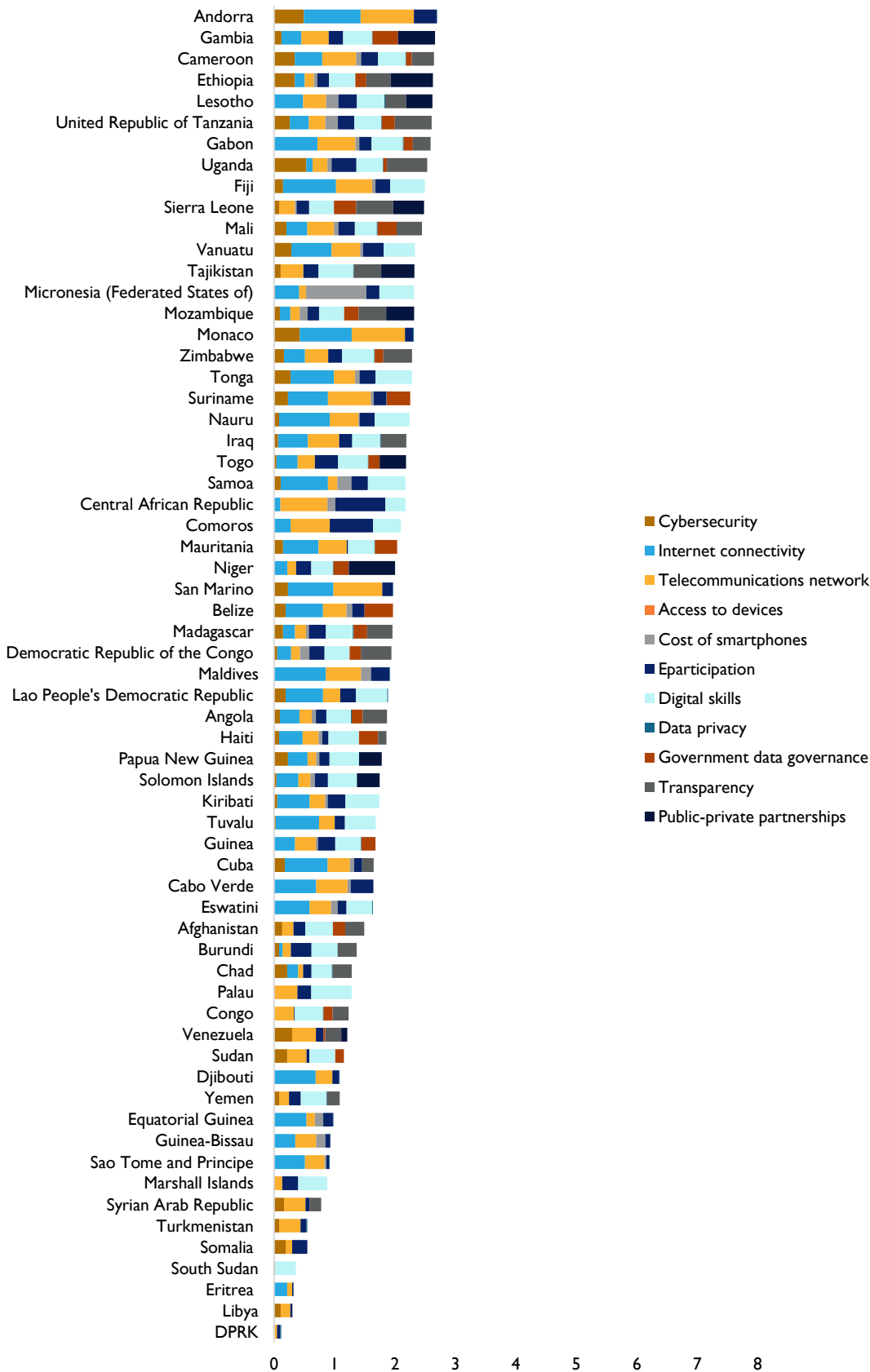


Table 6 – DPI typology, selected countries (in red = financial institutions required to adopt a DPI payment systems)

		DPI adoption		
		Low	Medium	High
DPI Readiness	High	<ul style="list-style-type: none"> • Portugal • Croatia • Luxembourg • Ecuador 	<ul style="list-style-type: none"> • Germany • Mexico • Thailand • USA 	<ul style="list-style-type: none"> • Brazil (mandatory after 500,000 active customers)⁸⁶ • Singapore • Japan • Belgium
	Medium	<ul style="list-style-type: none"> • Namibia • Bolivia • Nigeria 	<ul style="list-style-type: none"> • South Africa • Kenya • Ghana • Pakistan • Egypt 	<ul style="list-style-type: none"> • India (mandatory to all banks) • Kazakhstan • Philippines • Switzerland
	Low	<ul style="list-style-type: none"> • Chad • Guinea 	<ul style="list-style-type: none"> • Ethiopia • Tanzania • Angola 	<ul style="list-style-type: none"> • Mozambique • Zimbabwe

VI. CONCLUSION

DPIs are part of governments' GovTech journey to promote financial inclusion, innovation, and interoperable digital ecosystems, reduce corruption and revenue leakage, and help developing nations reach SDGs. Yet the analysis of the impacts of DPIs is still incipient, typically based on only the Indian experience and lacking comparisons or counterfactuals. This report has sought to summarize some of the gains from DPIs and the various challenges associated with DPIs and their rollout, and discuss the readiness of developing countries to implement DPIs. Some findings are as follows:

- Some DPIs have had striking benefits in promoting digital and financial inclusion, and public service delivery. In India and Brazil, payment systems UPI and Pix have had a breathtakingly rapid adoption and enabled poor people to use digital payments and access bank accounts.
- However, UPI and Aadhaar in particular have also faced cybersecurity challenges, and other DPIs such as Mexico's CoDi payment system have failed to get traction.
- The deployment, maintenance and governance of DPIs can be expected to require a solid enabling environment with data privacy regulations, cybersecurity capabilities, internet connectivity, and substantial capabilities among implementing countries' government agencies to promote adoption. Per the DPI Readiness Index developed here, most Sub-Saharan African and poorer Asian countries appear to be far from having the preconditions for successful DPI adoption and management.
- It is not clear that models such as UPI are sustainable, nor is it clear that governments implementing DPIs are able and incentivized to build on them and innovate further – as opposed to private providers that compete fiercely with each other and have a keen incentive to provide new value to their customers, and do so sustainably.
- There are notable competition policy challenges in countries where the Central Bank both manages a national payment system and regulates the payment market. There is more work ahead to ensure DPIs promote competition in the payments market and avert conflicts of interests.
- While UPI has been used for crossborder payments in some corridors, MSMEs seeking to engage in crossborder commerce need to rely on the world's private payment providers and the interbank Swift messaging system that enable payments among billions of points around the world, with excellent fraud track record of fraud prevention. Using a credit card also enables MSMEs to access financing.
- More work is needed to ensure that private sector solutions are “built-in” into DPIs' technical and business models from the start. A potentially useful model going forward in operating DPIs is a consortium model among public and private sector providers.

In general, the economic outcomes produced by the diverse models by which countries have developed their digital infrastructures require much more analysis. Subsequent studies seek to help accomplish this by promoting dialogue and empirical analysis on the merits and disadvantages of DPIs around the world.

ANNEX I

Table I-1 – Examples of DPI models used around the world

Name	Country	Type	Enables
Open Standards Identity API (OSIA)	Africa*	Digital ID	Eliminates vendor lock-in to help make interoperability for sovereign identity programs possible through a set of open standard interfaces
Transfers 3.0	Argentina	Instant payments	Facilitates transactions between the actors of the financial ecosystem through interoperable QR codes
NPP	Australia	Instant payments	Allows for credit transfer, merchant payment, and bill payment through internet/mobile banking and QR Code
Australian Business Register	Australia	Open Corporate Registries	Free public view of businesses in Australia
SCT Inst	Austria	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments

X-Road	Azerbaijan	Data exchange	State bodies to connect its information system and exchange data through the platform; allows access rights for other departments to facilitate interaction between citizens and the state
E-/M-residency	Azerbaijan	Corporate Digital ID	Access business banking and online payment service providers, declare taxes, file customs declarations for example to deal with the EU market, register new employees, sign documents electronically.
Civil Registration and Vital Statistics (CRVS)	Bangladesh	Digital national registry	Addresses child marriages by letting marriage registrars verify age from national ledger before officiating a marriage
SCT Inst	Belgium	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
QR BCB	Bolivia	Instant payments	Interoperable instant payment system that seeks to speed up transactions using QR codes
Pix	Brazil	Instant payments	Allows for increased speed, availability, convenience, and security for instant payments; giving rise to institutions that initiate payments with Pix
SITRAF	Brazil	Instant payments	Supports P2P and C2B payments, with payments made only via internet or mobile banking
National Identity Card	Brazil	Digital ID	Designed to give Brazilians secure and easy access to services used in daily life through biometric technology

Open Finance Framework	Brazil	Data exchange (financing)	Allows data on products and services, customers, and payment services to be available
Auxillo Emergenciar	Brazil	digital social assistance	Allows individuals to receive aid through the program where the government set up digital savings accounts with digital access channels to use the funds
	Brazil	Open Corporate Registries	
OrgBook BC	British Columbia	Corporate Digital ID	The online directory makes finding authentic and authoritative data about BC companies fast and easy.
SCT Inst	Bulgaria	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
	Cambosia	Open Corporate Registries	
TBA*	Canada	Digital ID	Intended to make governemtn services easier to access, more efficient, and secure
RTR	Canada	Instant payments	Gives businesses and consumers more transparency and access to their payments any time of any day
*no name for Instant payment system yet	Chile	Instant payments	Working towards instant, low-value payments
TEF	Chile	Deferred net settlement instant payment	credit transfer, direct debit, and e-money for bill, bulk/batch, and future dated payment
IBPS	China	Deferred net settlement instant payment	credity transfer and direct debit for bill payment and recurring payment

Instant Payment System (SPI)	Colombia	Instant payments	Created by a Payment System forum that aims to use public-private working groups to spur its development that will allow for open, interoperable, and low-cost SPI
Cédula Digital Colombia	Colombia	Digital ID	Provides further security for users, enables fast access to online public services, and can be used to travel to more than 10 South American nations
Sinpe (National Electronic Payment System)	Costa Rica	Instant payments	Allows money to be sent using the telephone number associated with a bank account and is also enabled for public transport
SCT Inst	Croatia	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
SCT Inst	Cyprus	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
NemID/MitID	Denmark	Corporate Digital ID	Users can access both public and private sectors, such as online banking, government websites, or engaging with one of the many businesses that use NemID.
SCT Inst	Denmark	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
e-ID	Ecuador	Digital ID	Improves Ecuadorian government's aim to improve the nation's digitization and efficiency to benefit citizens
Transfer365	El Salvador	Instant payments	Instant interbank payments through an automated clearing house used by commercial banks, savings and credit associations, and other authorized institutions
e-ID	Estonia	Digital ID	Allows citizens to efficiently interact in public and private sectors, like paying bills, voting online, signing contracts, shopping, accessing health information and more

X-Road	Estonia	Data exchange	Cross-border interoperability between countries using the system; improves information accuracy and security, especially when exchanging data between governmental agencies, like population data
E-Residency	Estonia	Corporate Digital ID	e-Residents can establish a trusted EU company online in one day, manage the resulting company fully online, conduct secure e-banking, access international payment service providers, digitally sign and transmit documents, and file Estonian taxes online.
SCT Inst	Estonia	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
FarmStack	Ethiopia	Data exchange (agriculture)	Powering data transfer in agriculture to increase collaboration and boost productivity
India Stack	Ethiopia*		Open APIs and public goods that aim to make identity, data, and payments effortless and attainable for all
eIDAS	European Union	Corporate Digital ID	eIDAS enables EU businesses to use their own national electronic identification schemes (eIDs) to access public services available online in other EU countries.
Digital Product Passport	European Union	Data exchange (supply chain)	Unique ID assigned to every product that will record all supply chain activities for that product using interoperable data exchange standards
TARGET Instant Payment Settlement (TIPS)	European Union	Real-time instant payments	Enables financial institutions to carry out instant credit transfers at any time and at a low cost; operates on a full cost recovery and not-for-profit basis
Payment Services Directive (PSD2)	European Union	Data exchange (financing)	Rules to regulate payment services and payment service providers throughout the EU, increasing competition and participation in the payments industry

X- Road	Finland	Data exchange	Cross-border interoperability between countries using the system; improves information accuracy and security, especially when exchanging data between government agencies, like population data
SCT Inst	Finland	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
SCT Inst	France	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
Health Data Hub	France	Data exchange (digital health)	Aggregates administrative data from different sources and confers interoperability from external databases
FranceConnect	France	Digital ID	Allows individuals to use existing credentials to authenticate their identity securely when accessing online services
Chorus Pro	France	e-invoicing	E-invoicing platform for B2G, B2B, and B2C transactions; introduces efficiencies, cuts costs and fights fraud by automating processes for tax authorities
SCT Inst	Germany	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
SCT Inst	Greece	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
MOSIP	Guinea	Digital ID	Biometric enrollment, identification, and de-duplication functions to give full control of private and personally identifiable information to citizens
Open API Framework	Hong Kong	Data exchange (financing)	Offers product info, customer data, account data, transaction data

FPS	Hong Kong	Real-time instant payments	credit transfer, direct debit and e-money for merchant, bulk/batch, bill payment and request to pay
UPI	India	Instant payments	Supports credit transfer, direct debit, and e-money to enable merchant payments, bulk payments, bill payment, and foreign inward remittance
Aadhaar Enabled Payment System (AePS)	India	Instant payments	Allows customers to access and transact on their bank accounts using their authenticated Aadhaar information
Aadhaar Payment Bridge (APD)	India	Instant payments	Allows for electronically channeling of Government benefits and subsidies in Aadhaar Enabled Bank Accounts of intended beneficiaries
Bharat Bill Payment System (BBPS)	India	Instant payments	Provides a centralized platform for payment of phone, utility, and other bills
IMPS	India	Real-time instant payments	Credit and e-money for P2P payments and foreign inward remittance
Aadhar	India	Digital ID	Unique 12-digit ID number linked to biometric, demographic, and contact information; enables various systems to work in India
eKYC	India	Digital ID	Electronic authentication of user's identity using Aadhar details
eSign	India	Digital ID	Lets Aadhaar holders digitally and remotely sign documents with a legally valid e-signature
GSTN	India	Digital ID	Unique 15-digit identifier assigned to businesses and individuals to track and manage tax liabilities and compliance of registered taxpayers under the GST system

Udyam	India	Digital ID	Registration system for MSMEs that make access to government schemes and benefits easier
DigiLocker	India	Data exchange	Provides an account in cloud to every Aadhaar holder to access authentic documents
OCEN	India	Data exchange (financing)	Secure sharing of customer credit information across Indian banks, fintech companies, and other financial institutions, including rural areas
ABDM	India	Data exchange (digital health)	Bridges gap between disparate digital health systems through a health ID registry, healthcare professionals, and healthcare facilities. Allows public and local digital healthcare players to provide patients with access to accurate information and access to health services remotely
Open Network for Digital Commerce (ONDC)	India	Open e-commerce platform	Connects buyers and sellers across multiple ecommerce platforms; supports economic growth by reducing entry barrier for small businesses through reduced operations costs and increased access to wider markets
National Urban Innovation Stack (NUIS)	India	Urban planning	provides cities with technology solutions to address urban challenges; empowers governments to create smart cities
BI Fast	Indonesia	Instant payments	Facilitates near-instantaneous transactions, allowing individuals or businesses to send and receive money. Includes instant bank transfers, mobile payment apps, and digital wallets
e-KYC	Indonesia	Digital ID and Data exchange	Ensuring all citizens have a Resident Identification Number to easily transact with government agencies and businesses both online and in-person
National Smart Card	Iran	Digital ID	Increase oversight and transparency to combat corruption and fraud, allowing citizens to gain access to their information and government benefits with ease through the digital ID
	Iran	Open Corporate Registries	

SCT Inst	Ireland	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
SCT Inst	Italy	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
NIDS	Jamaica	Digital ID	Promote inclusion by enabling people with different forms of disability to access social services
Zengin	Japan	Instant payments	Consumers and businesses can make payments immediately at a low transaction cost and with minimal risk
	Japan	Open Corporate Registries	
PesaLink	Kenya	Deferred net settlement instant payment	Credit transfer for bulk payment and bill payment
Kenya Agricultural Observatory Platform (KAOP)	Kenya	Data exchange (agriculture)	Online platform that gathers data on crop performance, climate patterns, and soil health to help farmers determine productivity. Increases food security, labor productivity, and promotes sustainable agriculture
	Kenya*	Digital ID	Expand access to digital government services and improve how citizens interact with the government

ESI	Kyrgyzstan	Digital ID	Single entry-point for citizens and business organizations into all state e-service portals
SCT Inst	Latvia	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
SCT Inst	Lithuania	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
SCT Inst	Luxembourg	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
RPP	Malaysia	Deferred net settlement instant payment	Credit transfer and e-money for merchant and bill payment
SCT Inst	Malta	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
SPEI (Interbank Electronic Payment System)	Mexico	Real-time instant payments	Allows general public to make electronic payments vis bank, Internet, or mobile banking
CoDi	Mexico	Real-time instant payments	Speeds up transactions and reduces the use of cash through QR codes, NFC technology, and payment links
SCT Inst	Monaco	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments

India Stack	Morocco*		Open APIs and public goods that aim to make identity, data, and payments effortless and attainable for all
X-Road	Namibia	Data exchange	Cross-border interoperability between countries using the system; improves information accuracy and security, especially when exchanging data between governmental agencies, like population data
eHerkenning	Netherlands	Corporate Digital ID	Companies can log in to more than 400 different organizations, such as UWV (Employee Insurance Agency), Chamber of Commerce and the Tax Authorities, as well as at municipalities, provinces and water boards and a number of private organizations.
SCT Inst	Netherlands	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
NIP	Nigeria	Deferred net settlement instant payment	Credit transfers, direct debit, and e-money for merchant or bill payment via internet/mobile banking, POS, branch, ATM, agent, and USSD
e-ID	Nigeria	Digital ID	Offers strong authentication and digital signature, and also works as a payment card
	Pakistan	Open Corporate Registries	
Digital Vale	Panama	Instant payments	Expedited welfare payments, initially meant to alleviate effects of the pandemic
Documento Nacional de Identidad (DNI)	Peru	Digital ID	Enables authorities to use the ID number to cross-check social insurance and other administrative data, ensuring government support reached those most in need

Electronic Wallet Interoperability	Peru	Instant payments	Mandated interoperability between Peru's most popular electronic wallets, Yape and Plin. Next steps are to include remaining banks, fintechs, and other licensed financial institutions
InstaPay	Philippines	Instant payments	Instantly transfer money from bank or e-wallet to a different one
PhilSys ID	Philippines	Digital ID	Allows for increased access to government assistance programs
Open Finance Framework	Philippines	Data exchange (financing)	Financial institutions can participate on a voluntary basis in a pilot that will cover public information, subscription and account opening, account information, payment initiatives, and more
India Stack	Philippines*		Open APIs and public goods that aim to make identity, data, and payments effortless and attainable for all
Express Elixir	Poland	Real-time instant payments	Credit transfer for merchant payment, bill payment, and request to pay
SCT Inst	Poland	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
SCT Inst	Portugal	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
	Russia	Open Corporate Registries	

Nusuk Hajj	Saudi Arabia	data exchange (religion/tourism?)	Enhances spiritual journey for pilgrims and ensures their safety by minimizing wait times and streamlines completion of necessary rituals during the Hajj pilgrimage for those of Muslim faith. Allows authorities to monitor movements of pilgrims in real time and prevents overcrowding to ensure safety
Modular Open-Source Identity Platform (MOSIP)	Sierra Leone	Digital ID	Open APIs and public goods that aim to make identity, data, and payments effortless and attainable for all
FAST	Singapore	Deferred net settlement instant payment	Credit transfer, direct debit, and e-money for merchant and bill payments
SingPass	Singapore	Digital ID	Allows users to access various government services online conveniently and securely through biometric data
Corppass	Singapore	Corporate Digital ID	Allows for businesses and other entities to transact online with government agencies
OpenCerts	Singapore	Digital academic certificate	Bolsters the robustness of education systems and delivers fair practices for employment by enabling accurate, low-cost qualification checks
Singapore Financial Data Exchange (SGFINDEX)	Singapore	Data exchange (financing)	Ensures integrity and user protection by enabling people to access and understand how their financial data is used by government agencies and private service providers
TradeTrust	Singapore	Data exchange (trade)	Exchange of trade documents between governments and businesses, and document verification

PayNow	Singapore	Instant payments	Enables transactions between member banks and financial institutions and links with payment systems in other countries; eliminates need for bank account numbers, reduces barriers to inter-bank transfers like cross-border remittances
SCT Inst	Slovenia	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
RTC	South Africa	Instant payments	Interbank electronic credit payment to allow transfer of funds within 60 seconds
TrueID	South Africa	Digital ID	Enables reliable fingerprint recognition in contactless form to confirm deliveries and other transactions with secure biometric authentication
Bank of Korea Financial Wire Network	South Korea	Instant payments	Allows for convenient payments through large-value settlement system, retail payment systems, securities settlement, and foreign exchange settlement systems
SCT Inst	Spain	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
	Spain	Open Corporate Registries	
India Stack	Sri Lanka*		Open APIs and public goods that aim to make identity, data, and payments effortless and attainable for all

BiR/Swish	Sweden	Real-time instant payments	the system allows real-time settlement of fast payments even during times when other settlement facilities (eg the central bank real-time gross settlement system) are closed. The typical time between payment initiation and availability of final funds to the payee for a successful fast payment transaction is one to two seconds. More than half of the country's population uses the Swish mobile app to make fast payments
SCT Inst	Sweden	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
PromptPay	Thailand	Deferred net settlement instant payment	Credit transfer and e-money for merchant, bulk/batch, bill payment and request-to-pay and e-donation
NDID (National Digital IDentity Platform)	Thailand	Digital ID	Intended to provide flexible and highly secured method of self-identification for any Thai citizen
MOSIP	Togolese Republic	Digital ID	Open APIs and public goods that aim to make identity, data, and payments effortless and attainable for all
Novissi	Togolese Republic	Instant payments	Delivers contactless, emergency digital cash transfers
India Stack	Togolese Republic *		Open APIs and public goods that aim to make identity, data, and payments effortless and attainable for all
Instant and Continuous Transfer of Funds System (FAST)	Turkey	Instant payments	Reduces use of cash and offers continuous availability, enhanced speed, and diversity to payments

Digital ID for E-Devlet	Turkey	Digital ID	Access to digital government portals to use public services
UAE-Pass	UAE	Digital ID	Enables citizens, residents, and visitors to create a secure digital ID that provides access to public and private digital services in the UAE
DIFC Open Finance Lab Initiative	UAE	Data exchange (financing)	Allows for collaboration on open finance of business, customers, and economy among banks, fintech companies, regulatory bodies, and industry.
Diia	Ukraine	Digital ID	Digitalizing various aspects to public administration of services for citizens
UK Faster Payment	United Kingdom	Deferred net settlement instant payment	allows a payer to initiate a payment simply using the payee's mobile phone number. Funds are typically available to the payee within seconds of the payer initiating the payment transfer.
SCT Inst	United Kingdom	Real-time instant payments	Credit transfer for merchant, bulk/batch, bull and future-dated payments
FedNow	United States	Instant payments	real-time payments and automatic settlements between e-wallets and other payment platforms; seeks to improve economic resilience of small businesses by simplifying supply chain payments

INRIS (Integrated national Registration Information System)	Zambia	Digital ID	Ensures enhanced security to make it difficult for ineligible person to register and a Zambian citizen
Automated System for Customs Data (ASYCUDA)		Data exchange (trade)	Platform for managing customs data and processes; allows interoperability with local government systems through open APIs
International Aid Transparency Initiative (IATI) Registry			Records and tracks how aid money is spend

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