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Stacking up the Benefits

Lessons from India's Digital Journey

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Stacking up the Benefits: Lessons from India's Digital Journey
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ABSTRACT: Foundational digital public infrastructure (DPI), consisting of unique digital identification, payments system and data exchange layer has the potential to support the transformation of the economy and support inclusive growth. India's foundational DPI, called India Stack, has been harnessed to foster innovation and competition, expand markets, close gaps in financial inclusion, boost government revenue collection and improve public expenditure efficiency. India's journey in developing a world-class DPI highlights powerful lessons for other countries embarking on their own digital transformation, in particular a design approach that focuses on shared building blocks and supporting innovation across the ecosystem.

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Glossary

AA	Account Aggregator
API	Application Programming Interface; the mechanism by which application developers access the data or features of an underlying system.
AePS	Aadhaar Enabled Payment System
ATM	Automated Teller Machine
CBDC	Central Bank Digital Currency
CGA	Controller General of Accounts
CAG	Comptroller and Auditor General of India
DBT	Direct Benefit Transfer, a mechanism for transfer of cash to bank accounts of beneficiaries or the transfer of subsidy to a service provider on successful authentication of beneficiary.
DIKSHA	The Digital Infrastructure of Knowledge Sharing, a Digital Public Infrastructure in the education sector
DIVOC	Digital Infrastructure for Verifiable Open Credentialing
DPI	Digital Public Infrastructure
eKYC	Electronic Know Your Customer
FMIS	Financial Management Information System
GSTN	Goods and Services Tax Network
Interoperability	The ability of a digital system to exchange information and work with other digital systems easily.
IT	Information Technology
LPG	Liquefied Petroleum Gas
MSME	Micro, Small and Medium Enterprises
NIU	National Information Utilities
NPCI	National Payments Corporation of India
OCEN	Open Credit Enablement Initiative
ONDC	Open Network for Digital Commerce
Open Protocols	Protocols are a system of rules to enable digital communications between two or more parties. Open protocols are protocols where these rules are free to use by anyone.
Open Source	Descriptor for software where the underlying code is publicly available and may be reused by others
Open Standards	Open Standards are specifications of uniform technical criteria of a system or technology that anyone is free to implement without payment of royalties or need for licensing.

PAHAL	Pratyaksh Hanstrantrit Labh; LPG subsidy program
PAN	Permanent Account Number (Tax identification)
PDS	Public Distribution System
PFMS	Public Financial Management System
PMGKY	Pradhan Mantri Garib Kalyan Yojana; the main pandemic relief program
PPP	Public-private partnerships
QR Code	Quick Response Code
RBI	Reserve Bank of India
SARTTAC	South Asia Regional Training and Technical Assistance Center
SOE	State Owned Enterprise
Systems Integrators	An enterprise that specializes in implementing, planning, coordinating, scheduling, testing, improving and sometimes maintaining a computing operation
TRAI	Telecom Regulatory Authority of India
TSA	Treasury Single Account
UIDAI	Unique Identification Authority of India
UPI	Unified Payments Interface
USSD	Unstructured Supplementary Service Data

Executive Summary

India has developed a world-class digital public infrastructure (DPI) to support its sustainable development goals. DPI refers to a set of shared digital building blocks, such as applications, systems, and platforms, powered by interoperable open standards or specifications. India Stack is the collective name of a set of commonly used DPIs in India; it consists of three different layers—unique identity (Aadhaar), complimentary payments systems (Unified Payments Interface, Aadhaar Payments Bridge, Aadhaar Enabled Payment Service), and data exchange (DigiLocker and Account Aggregator). Together they enable online, paperless, cashless, and privacy-respecting digital access to a variety of public and private services.

The benefit of this investment is felt across the country and served India well during the pandemic. Aadhaar, helped facilitate the transfer of social safety net payments directly from the government treasury's accounts to beneficiaries' bank accounts, helping to reduce leakages, curb corruption and providing a tool to effectively reach households to increase coverage. The Government of India estimates that, up to March 2021, about 1.1 percent of GDP in expenditure was saved due to the digital infrastructure and other governance reforms. Using this digital infrastructure India was able to quickly provide support to an impressive share of poor households during the pandemic. In the first months of the pandemic about 87 percent of poor households received at least one benefit.

India Stack has been used as a platform to foster innovation and competition; expand markets; close gaps in financial inclusion; boost government revenue collection; and improve public expenditure efficiency. Digital payments are now ubiquitous, UPI accounts for 68 percent of all payment transactions by volume. The use of digital payments has expanded the customer base of smaller merchants, documenting their cash flow and improving access to finance. Roughly 4.5 million individuals and companies have benefited from easier access to financial services through the Account Aggregator, since it was first launched in August 2021, and adoption is increasing rapidly. Digitalization has also supported formalization of the economy, with around 8.8 million new taxpayers registered for the GST between July 2017 and March 2022, contributing to buoyant government revenues in recent years. Government service provision is streamlined; for example, citizens can access documents issued by state and central government through one platform. Similarly, the India Stack has digitized and simplified Know Your Customer procedures, lowering costs; banks that use e-KYC lowered their cost of compliance from USD 12 to US 6 cents. The decrease in costs made lower income clients more attractive to service and generated profits to develop new products.

India's journey highlights lessons for other countries embarking on their own digital transformation. India Stack's development is guided by a foundational building blocks approach, and a focus on supporting innovation across the ecosystem. The building block approach involves unbundling the components of the solution to a set of problems and identifying a minimal common core. This modular approach fosters innovation, allowing solutions to be built to multiple problems based on the common core. For a large and diverse country such as India, a building block approach provides those closer to the problem with the basic tools to create tailored solutions. A focus on supporting a vibrant ecosystem implies the need for interoperability between the different DPIs and a competition-focused design. In India, interoperability was supported through open standards, allowing anyone to utilize the functionality provided by India Stack. These principles are applied to other DPIs in education and health, including the Covid-19 vaccine and distribution platform, CoWIN. Using a digital backbone allowed India to scale its vaccine delivery quickly and overcome challenges such as

large-scale internal migration. The technology underlying CoWIN has been deployed in Indonesia, Philippines, Sri Lanka and Jamaica to help facilitate their vaccination programs.

The government played a catalytic role, acting as an anchor client and establishing institutions to ensure continuity in India Stack's operations. DPI is an example of a two-sided market where the value of the platform increases for both participants as the numbers on each side increases. By using the DPI to provide social benefits, the government encouraged take up by individuals and gave service providers the comfort of access to a large client base. The government also promoted the use of technology as 'utilities' and created a category of not-for-profit companies with a public purpose (National Information Utilities). The National Payments Corporation of India, an initiative between the Reserve Bank of India and the Indian Banks Association, which unites and operates retail payments and settlement system, is an example of such a company. This is one strategy to strike a balance between curbing monopoly rents and providing these services effectively and efficiently, without the various human resources and procurement challenges that often plague large government projects. The tax administration also played a pioneering role in rolling out a tax ID (PAN) using an innovative PPP approach, from where important lessons were drawn to develop Aadhaar.

A set of enabling policies in the financial and telecommunications sector also supported the uptake of India Stack. In 2014, there was a push by the government to provide access to a no-frills, low-cost bank account, that doubled the coverage of individuals with bank accounts. The scheme targeted the financially underserved, especially rural women. Under this initiative 462.5 million of bank accounts were opened in both urban as rural areas as of August 2022. In late 2016, India enacted a demonetization policy where large currency notes were invalidated. While it was disruptive, demonetization led to greater use of other forms of payment, including the UPI. Sound policies, such as foreign investment liberalization and the prohibition of discriminatory data tariffs, led to a competitive, open, and affordable telecommunications market. The entry of a new network operator in 2016 lowered the cost of mobile data by 90 percent leading to a jump in data usage from 154 MB/month in 2015 to 15.8 GB/month in 2021.

Certain features of India's journey would be difficult to replicate elsewhere, but these are not preconditions for success. The in-house development of Aadhaar, supported by systems integrators firms, was feasible in India due to the high level of capacity in IT within its domestic labor market. This allowed India to avoid vendor lock-in and lack of interoperability and created a need for sufficient resources and capacity to continue maintaining and developing the infrastructure. Other countries have approached this challenge differently, including by using open-source software under the format of digital public goods shared between countries. These types of resource and knowledge-sharing initiatives mean that governments with shallower IT capacity can implement DPI. There are also features arising out of India's specific context which may not be applicable for others. For example, to access the full functionality of India Stack, individuals need access to a smartphone and a bank account. For other countries with low adoption of smartphones and lack of access to banks, payments systems based on mobile money that can be used on a feature phone are the dominant form of digital payment.

To maximize India Stack's potential there are challenges to be addressed. Despite significant progress, digital literacy remains low in India, and represents a barrier to engaging with DPI-based solutions. The digital divide appears along familiar geographic, gender and income lines. A mere 14.9 percent of rural households have internet access, compared to 42 percent among urban households. Women are more likely to be digitally illiterate, particularly among low-income groups. The authorities are working to address this issue through various training initiatives as well as public access outlets, where users are supported to access government

services. Accessibility of UPI on feature phones and offline modes are also being explored. Comprehensive data protection legislation is still missing in India. A robust data protection framework is essential to protect citizens' privacy, prevent companies and governments from indiscriminately collecting data, and holding companies and governments accountable for data breaches to incentivize appropriate data handling and adequate investments in cybersecurity. The DPI can also help support efforts to make social assistance more resilient and adaptable. For example, Aadhaar can be used to exchange data between various schemes across states. Finally, leveraging the DPI, India could improve significantly the timelines, quality, and coverage of the general government fiscal reports, enhancing at the same time fiscal transparency for its citizens, a key issue to improve public sector accountability.

Digital Public Infrastructure Ecosystem

India has significantly advanced on its development goals, increased efficiency in the public sector and unlocked innovation in the private sector by adopting the approach of building Digital Public Infrastructure (DPI). Digitalization has been known to improve efficiency and transparency in government processes. More broadly, digital transformation of the government can improve policy implementation and can widen the range of policy options (Gupta et al, 2017). However, a piecemeal approach to digitalization could lead to the adoption of siloed digital solutions that are not the most efficient nor citizen friendly. Information systems that are built too narrowly for a particular context also face technical challenges as governance objectives and societal conditions evolve, requiring major upgrades or maintenance. The key idea behind DPI is not digitalization of specific public services, but rather building minimal digital building blocks that can be used modularly by government as well as private players to enable society-wide transformation. Adopting the approach of building DPIs reduces redundant effort, increases maintenance efficiency, and provides highest leverage as improvements to the specific digital building block are shared across multiple domains in one shot.

DPIs are a set of shared digital building blocks powered by interoperable open standards or specifications. DPIs act as digital building blocks to drive innovation, inclusion, and competition at population scale. In technical terms, these are either networks, systems or platforms that allow programmatic and secure access to the underlying data and business logic through Application Programmatic Interfaces (APIs). APIs allow solution builders to use some or all these DPIs as per the context of their specific solution. Such loosely coupled technologies that work well together to deliver a final solution is called a "stack". India Stack, which stands for "digital stack in India", is the collective name of a set of commonly used DPIs in India,[1] which consists of three different layers - i. identity, ii. payments, and iii. data - that enable online, paperless, cashless, and privacy-respecting access to a variety of public and private services (Table 1). DPI differs from the simple provision of services via digital channels, as the crux of DPI is that it empowers others to utilize the infrastructure in their own applications.

Since DPIs are foundational infrastructure, they need to address issues of sovereignty and control. This includes operating under a set of enabling rules made by an open, transparent, and participatory governance mechanism. They are called "public" because they allow for equal and non-discriminatory access to individuals or institutions as per the rules of governance, and not because they are provided as a public service[2]. In broader terms, the denomination as "public", from an economic perspective derives from the public provision of a private good, in the same way as provision of education or health services by the public sector. For a specific DPI, since many are developed in open source software, and it is shared freely with other actors by putting it in the public domain without any restrictions for its utilization, the principle of non-rival could be accomplished[3]. But the non-exclusion principle is only achieved by an explicit decision of the proprietary owner to not exclude any actor from its utilization, as is the case of the India Stack[4]. If digital utilities adhere to these principles of openness and transparency, DPIs may be built by governments, as well as by private or third sector parties. On one side, positive externalities associated with the provision of an open, interoperable digital infrastructure

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[1] See more details at www.indiastack.org and www.ispirt.in.

[2] A broader discussion about the relationship between DPI, building blocks and digital public goods is presented in Digital Public Goods Alliance (2022).

[3] India Stack uses open source software for internal components, but is not itself open source.

[4] Due to privacy and other concerns, there may be some conditions on access such as requiring registration with the regulator and requiring cybersecurity audits. However, these conditions are applied equally to all applicants in a non-discriminatory fashion.

provides some grounds for the public provision of such digital infrastructure. On the other, there can be drawbacks associated with public provision, such as challenges in ensuring that innovation continues within each layer itself, as well as providing resources for long run maintenance and upgrading.

Name	Definition	Year of Launch	Operating Body
Table 1: Layers of India Stack			
Identity Layer			
Aadhaar	A 12-digit unique identification number that is linked to biometric (fingerprints, iris, face) demographic (name, age, gender, address) and optional contact details (email, phone number)	2009	Unique Identification Authority of India (UIDAI)
eKYC	Electronic authentication of a customer's identity using their Aadhaar details	2013	Unique Identification Authority of India (UIDAI)
eSign	Service enabling Aadhaar holders to digitally and remotely sign documents with a legally valid electronic signature	2016	Controller of Certifying Authorities (CCA)
GSTN	A unique 15-digit identifier assigned to businesses and individuals who are registered under the GST regime in India. It is used to track and manage the tax liabilities and compliance of registered taxpayers under the GST system.	2017	The Goods and Services Tax Network (GSTN)
Udyam	A registration system for MSMEs in India, to make it easier for MSMEs to access government schemes and benefits.	2020	The Ministry of Micro, Small and Medium Enterprises (MSME)
Payments Layer			
AePS (Aadhaar Enabled Payment System)	An interoperable financial system allowing customers to access and transact on their bank accounts by authenticating their Aadhaar	2010	National Payments Corporation of India (NPCI)[5]
APB (Aadhaar Payment Bridge)	System for electronically channeling the Government benefits and subsidies in the Aadhaar Enabled Bank Accounts (AEBA) of the intended beneficiaries.	2011	National Payments Corporation of India (NPCI)
UPI	Unified Payments Interface is an instant real-time payment system	2016	National Payments Corporation of India (NPCI)
BBPS (Bharat Bill Payment System)	Integrated bill payment system providing a centralized platform for the payment of telephone bills, utility bills, etc.	2016	National Payments Corporation of India (NPCI)
Data Layer			
DigiLocker	Digitalization service that provides an account in cloud to every Aadhaar holder to access authentic documents	2015	Ministry of Electronics and Information Technology (MeitY)
Account Aggregator	Enables consented access and sharing any person's digital financial information in a secure manner among financial institutions regulated by Financial Sector Regulators, viz., RBI, Securities and Exchange Board of India (SEBI), Insurance Regulatory and Development Authority of India (IRDAI), Pension Fund Regulatory and Development Authority (PFRDA	2021	Reserve Bank of India (RBI)

DPIs share many similarities with other approaches to digitalization of the government, such as GovTech or Government-as-a-Platform, while a key difference is in terms of scope. GovTech refers to the delivery of citizen-centric digital public services. Government-as-a-Platform, in a similar manner to DPIs, advocate for the government to provide canonical data and APIs that the private sector can build upon (Pope, 2019, and O'Reilly). The key difference is that the former focuses on transforming government, while the latter focuses on moving to a digital society**.** For example, the Unified Payment Interface (UPI), is a fast payment system, used largely for peer-to-peer payments and is also the most popular peer-to-merchant retail payment system in India with monthly transaction volumes of 8 billion in December 2022 (NPCI, 2022). However, UPI itself is not utilized by the government for any public service delivery.

Box: 1 What is UPI?

The Unified Payments Interface (UPI) is an instant, real-time fast payment network built, owned and operated by the National Payments Corporation of India (NPCI). The payment system is built as an interoperable protocol. This allows anyone to build an app providing payments as a service to all customers of participating banks. It is in effect, a 5-party system – the central switch, a bank and payment system provider (PSP) for the remitter and the beneficiary.

Due to interoperability, customers with an account in Bank "A", can use a payments app built by PSP "B" to send money from their account to customers of any other bank or PSP participating in UPI via QR codes, cell phone numbers or other identifiers. The payments are settled instantly and for nearly free. As of December 2022, there were over 7.82 billion transactions per month on the UPI network by over 260 million unique users.
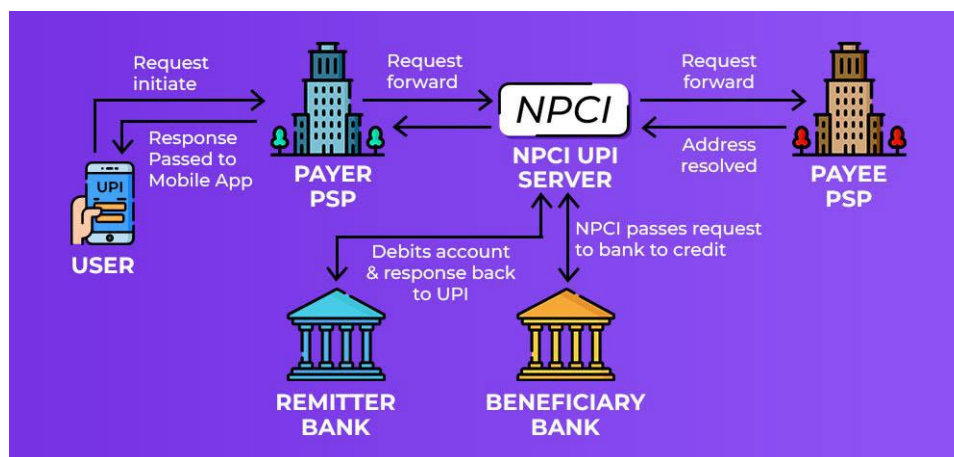
Source: GeeksForGeeks (2022)

The NPCI, is a not-for-profit initiative of Reserve Bank of India (RBI) and Indian Banks' Association (IBA) set up under the provisions of the Payment and Settlement Systems Act, 2007, for "creating a robust Payment & Settlement Infrastructure in India". It is a regulated entity with various private and public sector banks on its board.


Using Digital Public Infrastructure

A platform for innovation

DPIs allow for innovative and convenient public and private services, help overcome inclusion or accessibility barriers, and increase transparency and accountability with real-time data. For example, in 2014, the government of India launched a Biometric Attendance System for the public servants based on Aadhaar, the digital identity program. This had two advantages – first-, it removed ghost employees from the payrolls of the government. Second, a public dashboard allowed citizens to track the data in real-time for every department of the government. The Biometric Attendance System was also used to reverse the burden of proof of life for pensioners. Earlier, senior citizens eligible for pension, many of whom were sick or infirm, had to present themselves to a government office and go through a paper process. Now, a postal worker with a portable biometric device can verify proof of life at their home. In the case of the private sector, banks used the same biometric identification to create an "Aadhaar ATM". Citizens could withdraw cash from their bank account with nothing more than their 12-digit identity number and their biometrics. This service was designed specifically for those who do not have a smartphone, are not digitally literate, or are not comfortable with using debit cards.

Reimagining existing information systems as a DPI can lead to opportunities for innovative private services across different sectors. In India, the Goods and Services Tax Network (GSTN) records invoice level data from every registered business in the country. Each invoice uploaded by the seller and accepted by the buyer is then used to calculate the input tax credit. This creates an incentive for businesses to work with honest suppliers who report their data faithfully and promptly. Recently the GSTN announced that this verified data will be made available in a machine-readable format through the Account Aggregator, a DPI framework that enables consented access and sharing of a person's digital financial data in a secure manner among financial institutions in the network framework (See table 1). This exchange of data will allow financial institutions to issue trade financing based on the business' verified tax returns, decreasing the risk as well as cost of underwriting the loan.

There have been multiple examples of successful private businesses that could only be possible due to the India Stack. In India, the digital-only zero-commission stockbrokers, Zerodha and Upstox, are the largest two brokerages by market share. They use the identity and payment layers of the India stack to create a seamless onboarding experience, allowing users to start trading from their mobile phones easily. A large majority of all new-to-trading investors choose these digital first brokerage firms for their investment needs. Zerodha now has more than double the market share of the largest traditional brokerage house, Angel Broking. These new digital-only financial entities are regulated under the same rules as their analog counterparts but have a much lower cost of acquisition due to their use of digital channels, leading to a growth in the investor base. The growing domestic investor base has led to large growth of domestic investments in Indian stock

markets, building resilience when foreign capital leaves in response to global macroeconomic conditions (Figure 1). There have been multiple lending startups that use all layers of the India Stack to service loans. One such example is the KredX platform that allows retail investors to participate in trade financing. It uses India Stack technologies to both onboard and transact with retail investors, as well as to verify the data of businesses whose loans they would be underwriting. The ease of collecting payments via QR code has also led to innovative ideas from the public. It is now common to see newspaper advertisements for social causes or for disaster relief with a QR code printed alongside for people to donate directly via the advertisement. More generally, India Stack has supported the development of a resilient digital economy, which grew 2.4 times

Figure 1: India Equity Inflows (USD billions)

Source: SEBI and AMFI

faster than the Indian economy as a whole and now accounts for 8.5 percent of gross value added in 2019 (Gajbhiye and others, 2022).
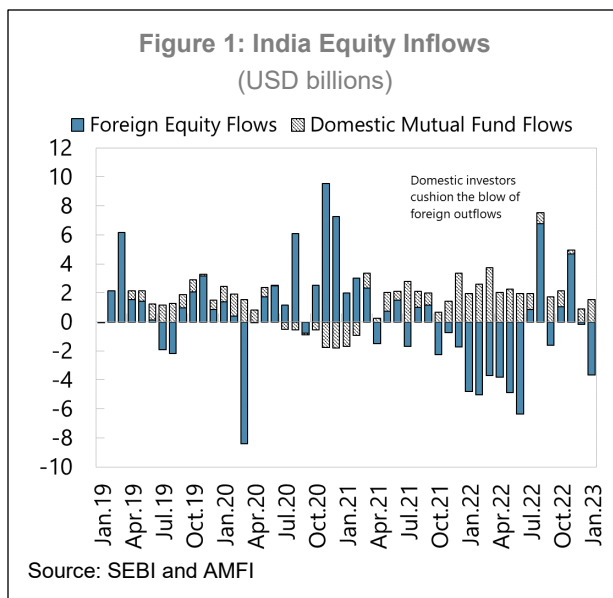
As the number of DPIs increases, the possibility for innovative applications grows exponentially by combining new services in a different way. With the availability of combining eSign, eKYC, Digilocker and UPI, new insurance companies in India can open accounts, enter contracts, disburse/collect money, and issue insurance policies directly into citizen's lockers without any physical interaction with the customer. The government of India has also recently announced the Bhashini platform, a national digital public platform for language translation. Since India has 22 official languages and thousands of dialects, translation is often a hindrance to communication. Bhashini aims to bring together the biggest open-source collection of translation example data, AI models and other research into a DPI that allows anyone to translate from any language to another in voice or text. This will allow users to further expand access to digital tools for underserved populations in India. There are more DPIs being built in health, education and other areas that will further help digitize society and create convenient, faster and more efficient public as well as private services (see New Initiatives section). This non-linear growth in innovation possibilities due to the building block nature of DPIs is often referred to as "combinatorial innovation" in India (Sukumar, 2021).

Fiscal Operations

Direct benefits transfers

India's main social safety net and subsidies programs are characterized by near universal rights-based programs, which faced high levels of leakage, inefficiency, and corruption. The largest program is the Public Distribution System (PDS) which provides in kind rice and grains. Other large programs are the public work program Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), the liquified petroleum gas (LPG) subsidy Pratyaksh Hanstrantrit Labh (PAHAL), the National Social Assistance Programme (NSAP), the Pradhan Mantri Awas Yojna- Gramin (PMAY-G) housing program, as well as many scholarship schemes. The PDS has suffered from corruption, in the form of identity fraud (e.g., duplicates, non-existent beneficiaries etc.) and quantity fraud (i.e., under-selling, diversion of wheat and rice) (Dreze et al,

2017). Eligibility fraud and exclusion errors have also plagued the PDS (World Bank 2011, Dreze and Khera, 2010). In 2012, an estimated 36 percent of total spending on the PDS never reached intended households because of ghost beneficiaries and the illegal diversion of subsidized goods by intermediating dealers (Ministry of Finance, Government of India 2017). In the PAHAL scheme which provided LPG cylinders under the market price, the dual pricing scheme led also to diversion of subsidized LPG cylinders to the open market. In addition, there were multiple ghost and duplicate beneficiaries. Governance issues were also present under the MNREGS.

To prevent leakages, the government introduced the Direct Benefit Transfer mechanism in 2013 for transferring benefits of various government schemes directly to bank accounts utilizing Aadhaar features as one key component. The Direct Benefit Transfer (DBT) is not a social assistance program in itself. It is mechanism to consolidate and control data on direct benefit transfers from multiple sources for 310 different government schemes managed by 53 ministries. The DBT, as a part of the Public Financial Management System (PFMS),[6] uses bank accounts numbers / Aadhaar linked account to directly transfer the social benefits to the beneficiaries. In particular, PFMS includes a Beneficiary Account Validation System that is integrated with commercial banks. Once the beneficiary list is provided by scheme holders (Central Government or State), the PFMS sends the beneficiary bank account details to the bank and it is validated through the bank account number or Aadhaar number to proceed to the payments through RBI and NPCI clearing houses respectively. PFMS evolved as a robust payment and reconciliation platform integrated with 600+ banks for verification of bank accounts and with NPCI for validation of accounts linked with Aadhaar numbers. At present, according to Ministry of Finance data, 54 percent of DBT payments are channeled through Aadhaar linked accounts and 46 percent through bank accounts. DBT is also used for in-kind transfers (e.g., the PDS), in this instance the Aadhaar authentication is used to access subsidized grains.

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[6] PFMS is the financial management information system of India.

Figure 2: Direct Benefit Transfer Workflow for Aadhaar Linked Accounts

Source: Ministry of Finance *Government of India*

Figure 3. Direct Benefit Transfer Beneficiaries
(In Millions, By Type)

Figure 4. Direct Benefit Transfer Payments
(By Program)

Source: Staff calculations and https://dbtbharat.gov.in/
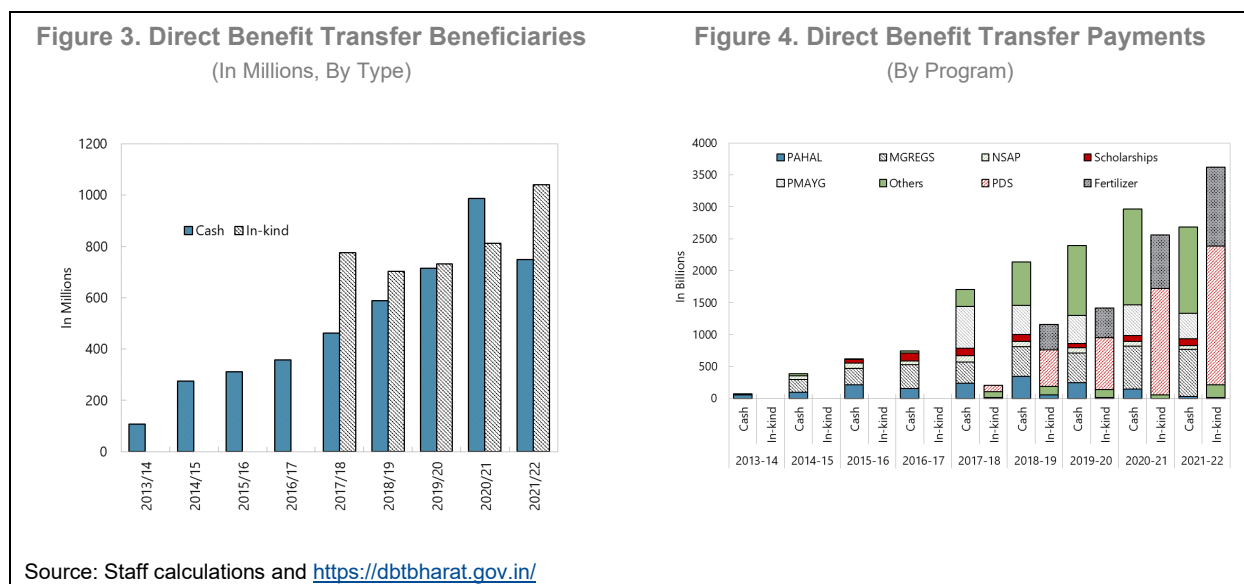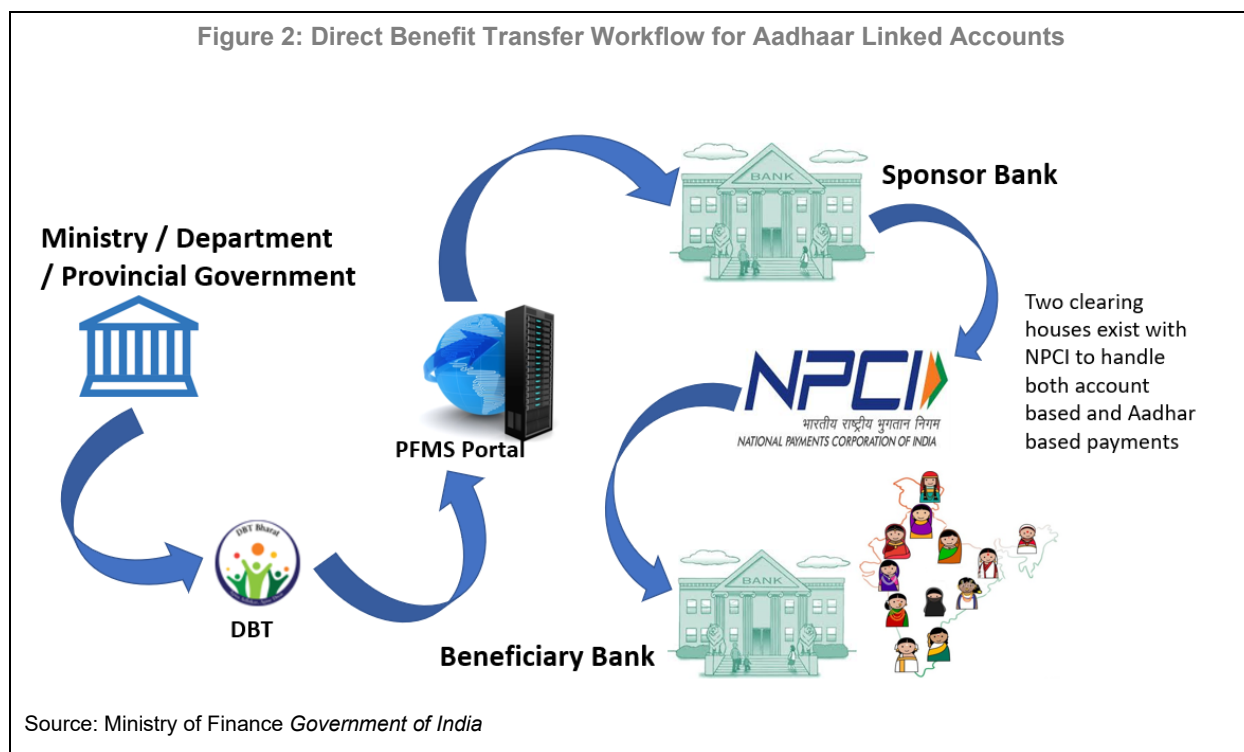
The main enablers of the DBT are the 'JAM trinity' - Jan Dhan, Aadhaar, and Mobile - that addressed identification issues and provided a delivery mechanism for social assistance programs built upon DPI initiatives. The first pillar, the Jan Dhan financial inclusion initiative, broadened access to bank accounts and financial services. Identification of beneficiaries is done through Aadhaar, the second pillar of JAM trinity. The bank accounts are also linked with Aadhaar numbers (Aadhaar Enabled Bank Accounts) and this is key for

channeling government benefits electronically.[7] The third pillar is the Mobile network, consisting of more than 960 million phones serving as an effective information exchange platform, especially in rural areas. It also enables households to use apps for accessing their banking information. In contrast to Sub-Saharan African countries mobile phones in India are not being used to deliver social assistance schemes (i.e., through mobile money). Notably, the JAM trinity does not allow for verification of socio-economic data of beneficiaries, the assessment of eligibility criteria is performed by scheme holders based on their databases.

Revenue administration

Tax administration agency of India has played a key role in promoting the adoption of DPI initiatives, such as unique identification number for individuals. Aadhaar in particular was a successor initiative of the Permanent Account Number (PAN) introduced by the Indian Income Tax Department (ITD) in 1972. The PAN is a unique, ten-character, alphanumeric identifier issued to all judicial entities identifiable under the Indian Income Tax Act, 1961. Recognizing the need for the unique national identification of taxpayers and transactions, by 1976 the use of PANs was mandated for tax purposes. Accompanied by a laminated identification card, PANs saw widespread use in other areas of public administration. This is reflected by the fact that far more PANs were issued than the number of active taxpayers under management at any one time (estimates suggest nearly 400 million issued in excess of active taxpayers). Aadhaar formalized the reality that a national identification solution beyond the scope of tax administration was required. In developing Aadhaar, it benefited from PAN's many lessons, notably incorporating the use of biometrics to reduce tax and financial fraud.

Aadhaar benefited from the lessons gleaned from PAN's implementation, particularly the adoption of a public-private partnership model in the allocation process. The number of PAN allottees increased exponentially following the out-sourcing of non-core activities (including allotment of PAN) performed by the tax administration on a public-private partnership (PPP) basis during the period 2003-04. With a view to improving the economy, efficiency, and effectiveness, reputed private firms were hired by ITD as managed service providers for processing of applications, collecting, handling, and verifying personal documents like proof of ID, age and address, clarification with the applicants, printing the laminated card and mailing. The adoption of PPP initiatives to deploy PAN were later replicated for Aadhaar roll-out. In Aadhaar, the use of private enrollment officers was instrumental in speedy rollout of the identity card to over a billion people.

Core tax administration operations rely heavily on DPI initiatives, where Aadhaar is expected to revolutionize tax administration compliance activities by promoting the consistency of registers across public agencies. An ongoing initiative to link PANs to Aadhaar is planned for completion by March 2023. At that time, PANs not linked to Aadhaar will become inoperative, representing a wholesale transition to reliance on the platform which will impact nearly all functions, from registration itself, to filing, payment and compliance casework. Already, more than 44 million PANs have been linked. The widespread adoption of Aadhaar has the potential to dramatically improve the use of third-party data for risk analysis and enforcement work at the tax administration. In practice, some forms of criminal evasion schemes that were previously difficult to detect and deal with will become considerably more challenging for those engaged in them. Beyond its use for mitigating deliberate evasion, the simple ability to access more current and up to date registration information is already improving the use of targeted education, outreach, and other essential taxpayer services. Further, the Aadhaar based eSignature DPI can be used to make an online application for PAN.

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[7] Some transfers are also being processed without Aadhaar numbers.

The Goods and Services Tax Network serves as an example of a specific DPI that has helped strengthen tax collection capability and simultaneously provide a platform for innovation. GSTN has consolidated the central government's ability to collect taxes across states, reduced corruption at the local level, and improved transparency through the implementation of open APIs. This has enabled easy third-party compliance built by private players via software. It also made invoice-level data on businesses readily accessible for trade financing when shared with user consent via the data-exchange layer. Every business that is required to pay Goods and Services Tax (GST) in India needs to register on the GSTN portal, which is managed by a non-profit organization that provides IT infrastructure and services for the implementation of the GST.[8] The registration process includes providing basic information such as name, address, and PAN. In the GST system, the invoices and supplier IDs are matched automatically. Matched invoices are settled by reconciling the data submitted by the buyer and the seller, ensuring that the correct taxes are paid and refunds credited in a timely manner. This also creates incentive for honest and timely reporting in supply chains. The number of newly registered GST taxpayers increased to 8.8 million between July 2017, when GST was introduced, and end-March 2022 (Figure 5).

Figure 5: No. of Registered GST Taxpayers (millions)

Source: Ministry of Finance, *Government of India*.

Source: Ministry of Finance
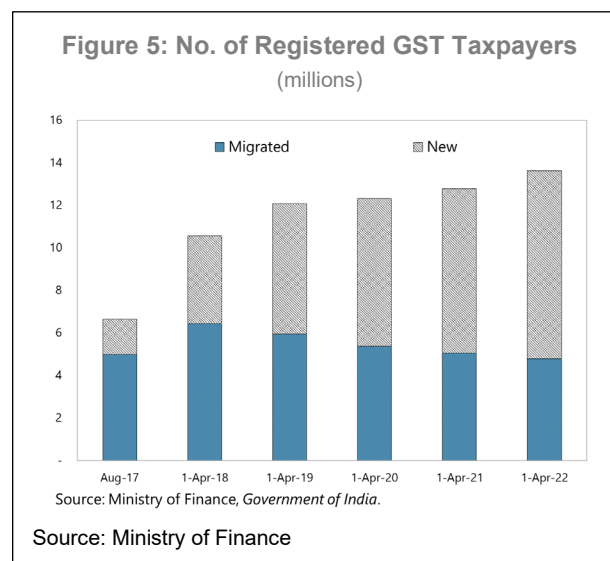
Treasury digital payments

Federal government's financial management information system (PFMS) is the backbone digital solution for managing fiscal operations in India. PFMS is managed by the office of Controller General of Accounts (CGA) of the MoF. CGA has been working on PFMS since 2008, laying down the financial pipelines that connect all tiers of Government. There are approximately 2.4 million implementing agencies below the federal level, 255 banks, and 380 million registered beneficiaries (29 percent of the population).

The PFMS covers both the spending side of the budget as well as collections of the GST and non-tax revenues. It facilitates online deposits through RBI for GST and directly in the PFMS for non-tax revenues, using internet banking and credit and debit cards, allowing transactions to be reconciled daily with a high level of accuracy. GST transactions alone peak at around 9 million per day. The PFMS works as a comprehensive financial management information system and has an important role in the DBT mechanism (though some benefit transactions are routed outside the system) leading to substantial financial savings to the Government. In relation to the payment ecosystem, PFMS includes automatic verification of beneficiaries' banking details, the use of Aadhaar, secure paperless and seamless payments through a web browser using digital signatures, and automated bank reconciliation and system-based accounts compilation.

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[8] www.gstn.org

By leveraging on DPI initiatives, the PFMS was able to seamlessly transfer funds to nearly 500 million beneficiaries during the COVID-19 outbreak, enhancing cash transfer programs' budget execution responsiveness and efficiency. The pandemic relief package, the Pradhan Mantri Garib Kalyan Yojana (PMGKY), was announced at the end of March 2020 and payments were made within two weeks of this announcement (Jain and others 2021). To enable these payments, the government of India leveraged its existing beneficiary's database in the PFMS, and other IT systems, including commercial banks systems, as well as accessing beneficiary data from various welfare schemes that also operate through the PFMS (Una, Verma, Bazarbash, and Griffin, 2023). From the public finance perspective, the benefits of adopting e-payments and digital ID, two key DPI, for cash transfers during the COVID-19 outbreak have helped improve budget execution responsiveness and efficiency of the cash transfers social programs, even in a context of social distance and restrictive mobility.

Social Sectors

Education

The DPI approach is also applied in the education sector to increase capacity and improve outcomes. India has a complex education system with 22 languages as medium of instruction, over 60 educational boards and each state having its own curriculum. The Digital Infrastructure of Knowledge Sharing (DIKSHA) is a digital infrastructure managed by the National Council of Educational Research and Training (NCERT) under the Ministry of Education for learning, designed to support multiple languages and solutions. DIKSHA is a free-to-use school platform with multiple solutions for students, teachers, and administrators, which include, for example, textbooks that link QR codes to relevant digital content, online courses with digital credentials, assessments, quizzes, and chatbots.[9] The platform is being leveraged and developed for school education, foundational learning programs, teacher capacity development programs, content crowd-sourcing program (VidyaDaan) and to support inclusive learning for underserved and differently abled communities of learners and teachers. It supports states and union territories to exercise autonomy, independence and choice to craft and run learning programs to suit their needs and achieve their goals. DIKSHA offers over 8,900 courses and 200,000 pieces of content across 30 Indian languages from 11,500 contributors, catering to over 60 educational boards across the country. Over the last five years and as of January 24, 2023, DIKSHA has clocked over sixty billion learning minutes in usage and seen over 135 million course completions, with a reach of approximately 180 million students and 7 million teachers. In the context of COVID-19 related disruption of schooling, DIKSHA made it possible for all states/UT's to enable learning/education at home through innovative state programs. DIKSHA is open-source software, open content, and open data, and thus its building blocks are available for use by other countries.

Since the underlying technology for DIKSHA is available as building blocks, it is being used not just in primary education but also in skill development. The Department of Personnel Training's Integrated Government Online Training modules by Ministry of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy, Ministry of Health and Family Welfare and Ministry of Sports and Youth Affairs are hosted on DIKSHA for COVID-19 training of doctors, nurses, and other health workers. Between April to June 2020 over 1.7 million individual trainings have been completed and certified. More courses are being added and DIKSHA is facilitating them.
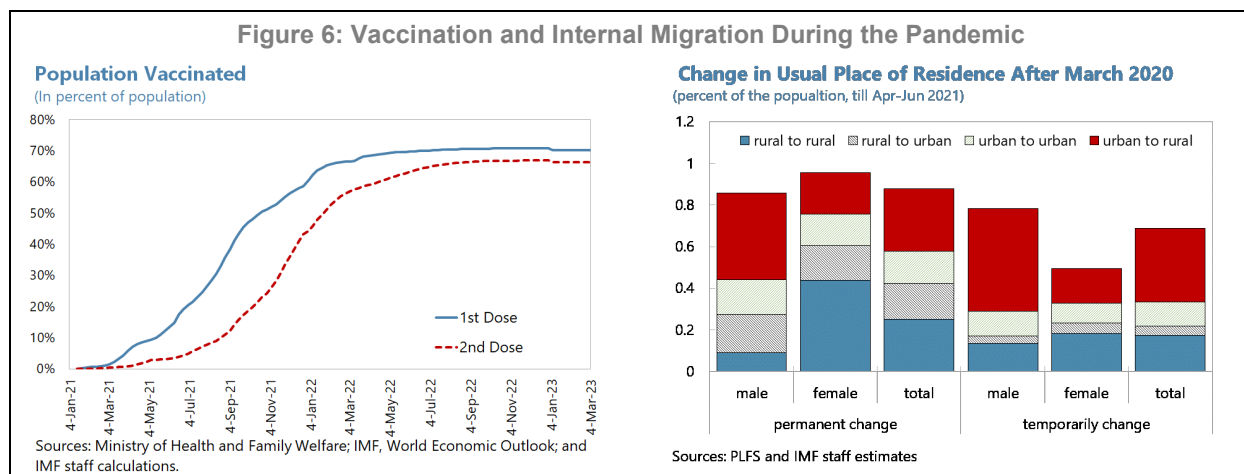
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[9] DIKSHA is built using MIT licensed open-source technology digital building blocks called Sunbird.

Health

India built its vaccine distribution and management platform CoWin as a DPI, supporting its ability to scale up vaccine delivery. The CoWIN platform was used for the end-to-end rollout of the Covid-19 vaccines. It was built using DIVOC (Digital Infrastructure for Verifiable Open Credentialing), an open-source software for digital certification. DIVOC was also deployed in four other countries (Indonesia, Philippines, Sri Lanka and Jamaica) to help facilitate their vaccination programs. CoWIN consisted of an app for residents to apply for a slot to get a vaccine, an app for healthcare providers to manage their vaccine inventory and the centralized issuing of vaccination certificates that were machine-readable, so that they could be easily used as vaccine passports. Using a digital backbone allowed India to scale its vaccine delivery quickly and overcome challenges such as large internal migration from urban to rural areas (Figure 6). Indians could take their first vaccine dose with one provider, and their second with another. The digital vaccination certificate was issued directly to the resident's DigiLocker, the digitalization service that allows every Indian to access authentic documents directly from the cloud. The availability of CoWIN as a DPI meant also that the government was able to provide vaccination services (slot booking, certificate download, etc.) over WhatsApp by using the CoWIN APIs.

Financial Sector

The lack of verifiable identification, low levels of financial literacy and inclusion, and the absence of historical financial data had hindered the provision of financial services to most of the population. In 2011, before the full implementation of the India Stack, only 1 out of 3 people had a bank account. The absence of a proof of identity was a major hurdle for financial institutions to onboard consumers, and to fulfill know-your-customer regulatory requirements.[10] Low levels of financial literacy exacerbated the challenge. For instance, in 2019 only 27 percent of the Indian adults met the minimum level of financial literacy level as defined by the RBI. These pervasive and persistent challenges contributed to a low take-up of financial services. For instance, only 8 percent were using products related to capital markets, while 13 percent leveraged pension related products, and 72 percent benefited from insurance products as of 2019.[11]

Figure 6: Vaccination and Internal Migration During the Pandemic

Population Vaccinated
(In percent of population)

Sources: Ministry of Health and Family Welfare; IMF, World Economic Outlook; and IMF staff calculations.

Change in Usual Place of Residence After March 2020
(percent of the popualtion, till Apr-Jun 2021)

Sources: PLFS and IMF staff estimates

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[10] Only 1 of 25 people had formal identification in 2008.
[11] Executive Summary: NCFE Financial Literacy and Inclusion Survey 2019

The DPI, particularly the identity layer, helped significantly enhance access to payment and financial services. Since 2011 financial inclusion in India has more than doubled and digital payments increased by 12 percent in 4 years (WBG Findex)[12]. There has been a significant increase in penetration of various financial services. The Aadhaar identity infrastructure allowed consumers to satisfy onboarding requirements of financial institutions. In addition, payment platforms run by the NPCI offered a basis to develop low-cost payment solutions based on open standards and protocols. The Aadhaar Enabled Payment System (AePS) allowed individuals to undertake transactions with authentication using Aadhaar. The Aadhar Payment Bridge allowed the government to make direct payments to beneficiaries. And UPI completed the package by allowing merchants and other firms to also make and receive instant and low-cost payments.

DPI initially led to greater adoption of traditional financial instruments, while digital instruments have been more widely adopted since 2017. According to the WBG, ownership of payment cards increased from 9 to 34 percent of the adult population, from 2011 to 2017, and savings at financial institutions rose from 12 to 20 percent. Also, the gender gap in financial services was reduced, with female ownership of bank accounts rising from 26 to 77 percent in the same 6-year period. This was supported by government initiatives to provide bank accounts to financial underserved

Figure 7. Financial Inclusion in India
(financial institution account %)

Source: WBG Findex (2021)

segments of the population (See Box 3). Since 2017, accounts at financial institutions shrunk by 2 percent, while uptake of e-wallets rose. This shift is not immediately visible in financial inclusion indices (Figure 7), which only track adoption of traditional financial instruments
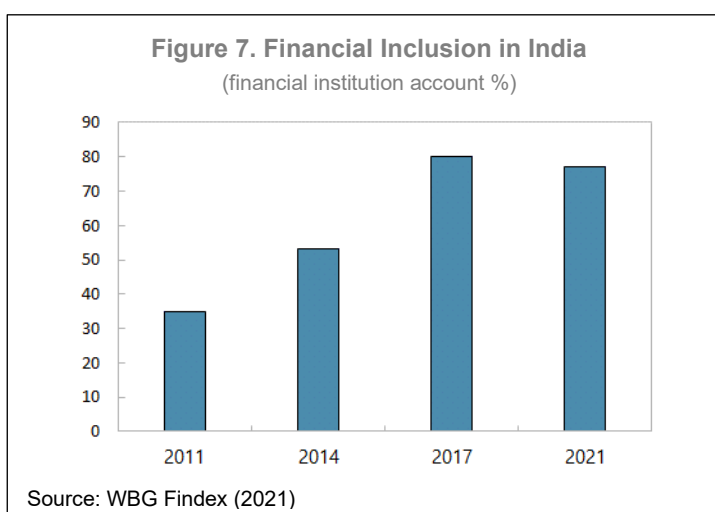
UPI has been widely adopted, benefitting from a user-friendly interface and incentives for private sector participation. UPI is used by all stakeholders, including individuals, and micro, small, and medium enterprises (MSME), especially smaller merchants. UPI was designed in a user-friendly way. It is easily accessible through mobile devices, provides convenient payment initiation methods, such as aliases, QR codes, and ensures universal interoperability between financial institutions. These design choices have helped enhance digital and financial literacy, and onboard segments of the population that were not formerly using financial services. UPI accounts for 75 percent of all payment transactions by volume in January 2023. In addition, UPI integration in well-established payment front-end solutions provided by popular firms such as Google Pay, PhonePe, and Paytm has created positive consumer experience and has spurred adoption.

The broader financial sector has benefited from access to financial data through the Open Banking – Account Aggregator (AA) Framework.[13] The framework enables customers to digitally access and share their financial data in a secure and efficient manner, through Account Aggregators who are registered and

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[12] Financial inclusion is measured by percentage of adult population with bank accounts
[13] Under financial data can fall banking transaction data, tax data, pensions data, securities data, insurance data.

regulated by the RBI. A consumer provides consent to the AAs to request data from Financial Information Providers (FIP) such as banks and share this data with Financial Information Users (FIU) which are registered with and regulated by any financial sector regulator (Figure 5). This framework enables consumers to benefit from their financial data to gain access to other services. As with the other India Stack initiatives the AA Framework is driven by public sector authorities to enhance competition and deepen inclusion.[14]

Figure 8: Account Aggregator Framework

Source: What is Account Aggregator? - Sahamati
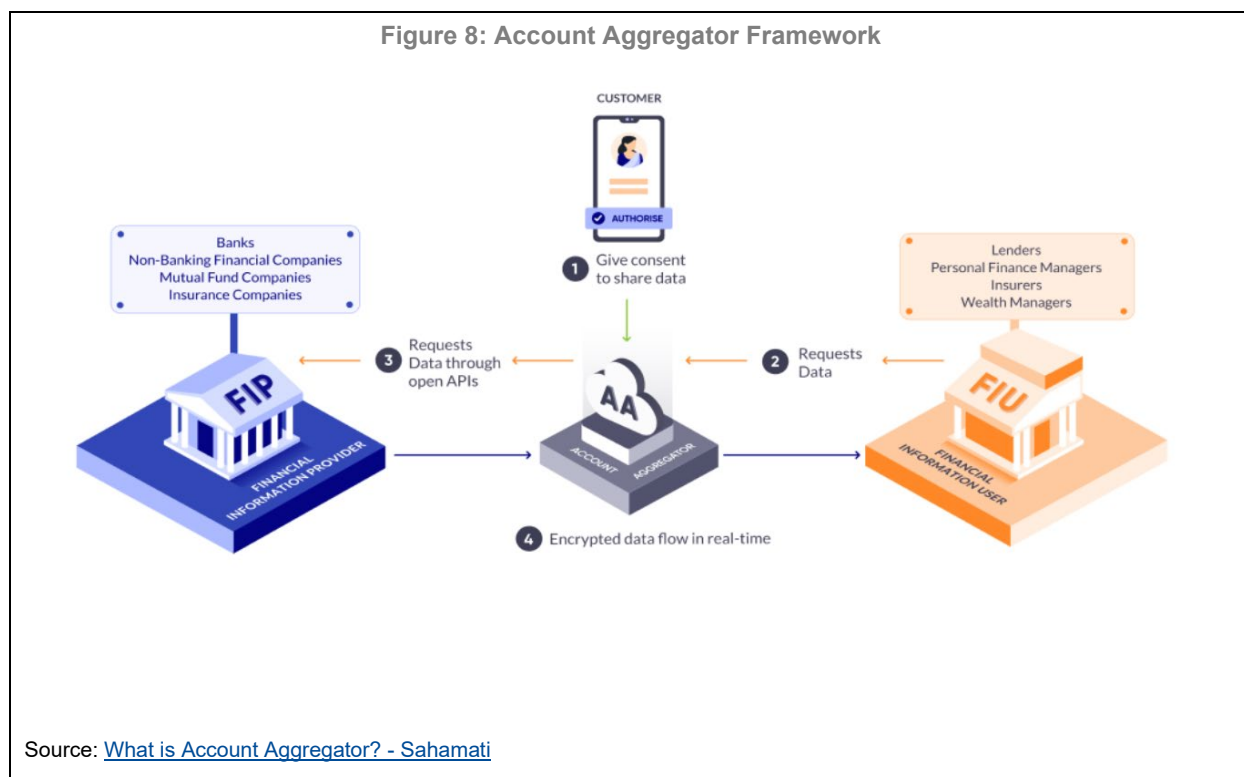
Building on the open data efforts, access to financial services has further advanced through the OCEN (Open Credit Enablement) initiative. Access to credit in India was one of the major problems restraining economic development. According to the Standing Committee on Finance less than 40 percent of MSMEs avail credit from formal financial systems and instead depend on costly and unreliable sources of credit. Based on the AA Framework principles, OCEN digitizes the lending process end-to-end. It standardizes the loan life cycle across financial institutions and marketplaces. Under the OCEN Framework, credit demand is shared with all potential lenders in the open network. All relevant data about the potential borrower is equally accessible to potential lenders. Borrowers are presented with multiple offers while competition in loan provision is enhanced.

Other Sectors

The government has also adopted the DPI approach in other sectors such as Electronic Toll Collection. India digitized its toll collection infrastructure through the creation of FasTag, a Radio Frequency Identification Technology based tag that is linked to a bank account or mobile wallet. The government first incentivized, then mandated the use of FasTag, and as a penalty, doubled the toll for cash payments. As of December 2022,

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[14] Inter-regulatory decision by the RBI, the Securities and Exchange Board of India (SEBI), the Insurance Regulatory and Development Authority (IRDA) and the Pension Fund Regulatory and Development Authority (PFRDA).

FasTag usage was responsible for 98% of the toll collections in India, with only 2% being cash[15]. It debits the bank account / mobile wallet linked to the tag's owner and credits the funds to the toll owner directly. This solution made the process more efficient and secure by saving time in cash handling and preventing leakage of toll collection revenue. The availability of FasTag also creates verified data of road usage, which helps the National Highways Authority of India monetize its assets under the Toll Operate Transfer model, a PPP model used by the Indian government to manage and operate existing toll plazas on national highways, allowing the government to reinvest capital in other construction and maintenance projects.

The Indian government also has created a single digital locker, known as DigiLocker, as a DPI for the issuance of all government documents in one place. DigiLocker gives one convenient place for citizens to view all documents issued by all departments of state and central governments. This is done using a federated architecture so that the data itself is still distributed across various ministries, but is available on request over APIs to every citizen. Before DigiLocker, to get an official copy of any document, such as a vehicle registration certificate, driving license or university certificate, citizens would have to queue up physically at the concerned office and verify their identity to get their own documents. DigiLocker allows users to

Figure 9: Take-up of DigiLocker

Source: DigiLocker

authenticate themselves via Aadhaar and download digitally-signed, tamper-proof copies of their documents across departments from one app. This especially helps those in rural households who would have to forgo a day's wages and incur travel expenses to collect a simple document from the administrative capital which could be in a distant urban centre.
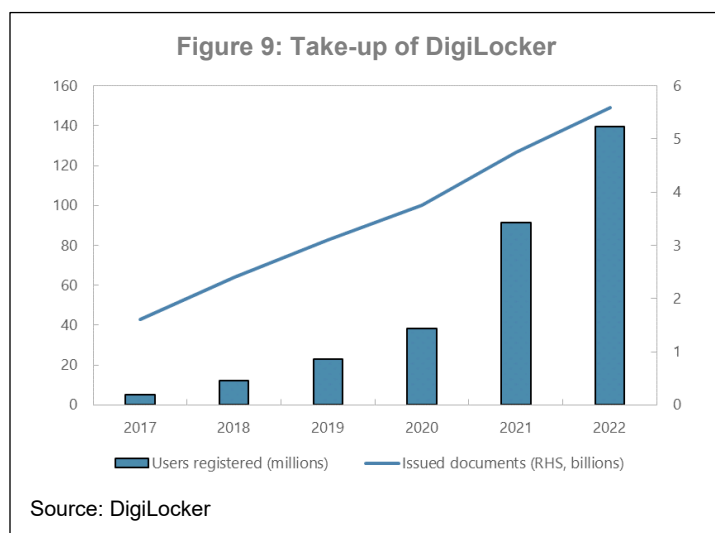
Reaping the Benefits

Macro implications of Digital Public Infrastructure

DPI has the potential to support the transformation of the economy and support inclusive growth. This section will present how India has harnessed India Stack to: foster innovation and competition; expand markets; close gaps in financial inclusion; boost government revenue collection; and improve expenditure efficiency, including through reducing leakages in the transfer of government benefits. Further progress in digitalization could improve India's productivity in the medium and long term, lifting potential growth above pre-pandemic levels (Kotera and Xu, forthcoming). In particular, considering only two channels (financial inclusion and lower leakages from social programs) DPI is estimated to boost GDP growth by 1-1.4 percentage points by 2030 in low- and middle-income countries (UNDP, 2022).

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[15] Press Information Bureau of India (@pibindia)," With more than 6.19 crore issued #FASTags enabling seamless movement and enhancing transportation efficiency, toll collection penetration has reached about 98%. #PromisesDelivered", Twitter, 16 January 2023 12:10 PM https://twitter.com/PIB_India/status/1614875273023094784

Digitalization, including through DPI, can foster macroeconomic resilience by developing a stronger and more agile social safety net to mitigate the impact of shocks on households. For instance, India's timely and targeted support during the early stages of the COVID-19 pandemic provided households with a consumption floor when their labor income was sharply reduced (Arbatli Saxegaard and others, forthcoming). More broadly, well-targeted transfers can reduce the volatility of output and significantly improve welfare (McKay and Reis, 2016; Kaplan and Violante, 2014). Empirically, government transfers have been found to mitigate labor market shocks in South Africa (Bellon, Pizzinelli, and Perrelli, 2020) and mobile money has allowed better risk-sharing in Kenya (Jack and Suri, 2014) and Tanzania (Riley, 2018). Timely-delivered support could also accelerate the recovery from climate shocks or other natural disasters (IMF, 2016).

Digitalization can enable better delivery of health and education services to accumulate human capital and foster growth. Stronger accumulation of human capital is essential to unleash India's growth potential (Kotera and Xu, forthcoming). And India's investments in digital health and education services are already paying off. CoWin helped manage the COVID-19 vaccination campaign and contributed to the reopening of the economy. The National Telemedicine Service, eSanjeevani, has served more than 92 million patients between its launch in November 2019 and end-January 2023 (eSanjeevani, 2023), whereas the number of households served by e-pharmacies tripled during the COVID-19 lockdown (FICCI, 2020). DIKSHA allowed instruction to move online during COVID-related lockdowns and provides resources for teachers and students to mitigate learning losses (World Bank, 2020). Hybrid learning, combining online resources with face-to-face interactions, could help teachers provide extra attention to struggling students (Dynarski, 2017).

Digital Public Infrastructure is a cost-effective investment. The creation of Aadhaar required the government to spend over USD 1 billion. This is because it required physical biometric enrollments to over a billion residents. However, at about USD 1 per enrollment, Aadhaar is still one of the cheapest identity projects in the world, due to its use of open-source software, open-source hardware, and minimal design (Atick, 2016). Subsequent DPI projects such as UPI have had a small outlay, such as building a central switch, but an oversized impact on the formalization of the economy. In the case of the open banking infrastructure, Account Aggregator, the RBI has published and enforced the standard, and private companies have invested in building applications implementing those standards.

Fiscal gains

Expenditure efficiency and adequacy

The DBT, in coordination with Aadhaar implementation, has helped to reduce leakages, curb corruption and provide a tool to effectively reach households to increase coverage. The DBT helps to reduce leakages in two main ways. First, for many programs, such as the PAHAL, Aadhaar identification numbers are linked to program beneficiaries to prevent "ghost beneficiaries" or "double dippers" that claim a benefit several times. Second, leakages were reduced by eliminating the so-called middle-men. Third, the DBT provides a tool, allowing for an alternative to the in kind provision of subsidies. Instead of providing in kind goods with a price below the market price, the government directly transfers the subsidy amount to the Aadhaar-linked bank account of beneficiaries. With this, the government bypasses middle-men involved in the delivery of the in-kind goods and dual pricing mechanisms. As proved during the pandemic, the DBT has also the potential to increase coverage swiftly as only the Aadhaar identification number and linked bank accounts are needed to provide benefits under the DBT. The DBT is also cost-effective. First, it reduces and has the potential to reduce

further the cost of the supply chain of in-kind benefits. Second, the use of one mechanism embedded in the PFMS reduced failure and delay of payments and the cost of transferring cash for scheme holders. For instance, it is more cost-effective for States with smaller schemes or schemes with small benefit amounts per beneficiary such as scholarship schemes to use the DBT mechanism as they don't need their own payment platform with higher unit costs. Finally, the DBT and JAM trinity increased overall beneficiary satisfaction (IISD, 2016).

The DBT undoubtedly led to significant savings but it is difficult to disentangle its effect from other developments. At the time of the introduction of the JAM trinity and adoption of the DBT for various schemes, broader macroeconomic developments and other policy developments that coincided are also key. For example, the adoption of the DBT for PAHAL coincided with lower international oil prices. Others have argued that, for PAHAL, the LPG subsidy regulation program – which started in 2013 – has been responsible for the identification and removal of invalid connections (Clarcke, 2016) instead of the Aadhaar component of the DBT. The Government of India estimates that up to March 2021, the government saved about 1.1 percent of GDP due to the DBT and other governance reforms (Table 2). Most of the savings are attributed to the elimination of duplicate, non-existent and ineligible beneficiaries. For the PAHAL, the termination of the dual pricing mechanism which eliminated governance issues around the supply chain also led to savings. Despite the difficulty in estimating the sole impact of DBT on reducing leakages, it is inevitable that it played and will play a key role in preventing future issues in government schemes.

Table 2. Estimated Savings from DBT and Related Reforms			
(Cumulative up to March 2021)			
Ministry/Department	Scheme	Savings (in billion Rs.)	Savings (in percent of GDP)
Department of Fertilizers	Fertilizer	100	0.05
Department of Rural Development	MGNREGS	335	0.17
Department of Rural Development	NSAP	5	0.00
Ministry of Women and Child Development	Others	15	0.01
Ministry of Petroleum and Natural Gas	PAHAL	729	0.37
Department of Food and Public Distribution	PDS	1016	0.52
Ministry of Minority Affairs	Scholarship scheme	14	0.01
Department of Social Justice and Empowerment	Scholarship scheme	3	0.00
Others	Others	12	0.01
Total		**2230**	**1.14**

Source: Staff calculations and https://dbtbharat.gov.in/estimatedgain

Using the DBT mechanism the government reached an impressive share of poor households to provide support during the pandemic. The PMGKY program was not a new scheme, rather a combination of pre-existing cash and food programs which have large outreach and strong delivery mechanisms. In the initial phase of three-months, PMGKY delivered cash transfers to 320 million beneficiary bank accounts through the PFMS[16]. Additional food rations were provided to 236 million households enrolled in the PDS database, covering nearly 72 percent of all households. LPG subsidies were provided via cash transfers through bank accounts to 80 million households. In the first months of the pandemic about 87 percent of poor households

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[16] Cash was scaled up through the MGNREGS, NSAP, PMJDY, Pradhan Mantri Kisan Samman Nidhi (PM-KSN) and support to construction workers through the Building and Construction Workers Welfare Fund. Food rations were provided through the PDS.

received at least one benefit under the PMGKY (World Bank 2021). Overall, 80 percent of all households received at least one benefit under the PMGKY scheme (Table 3). About 74 percent of households received food allocations. About 40 percent of all households received food transfers only, 34 percent received food and cash transfers together, and 6 percent received only cash transfers. Targeting of the poor was better compared to non-poor (87 percent receiving at least 1 benefit compared to 76 percent). Targeting was better towards rural households (85 percent receiving at least 1 benefit compared to 69 percent).

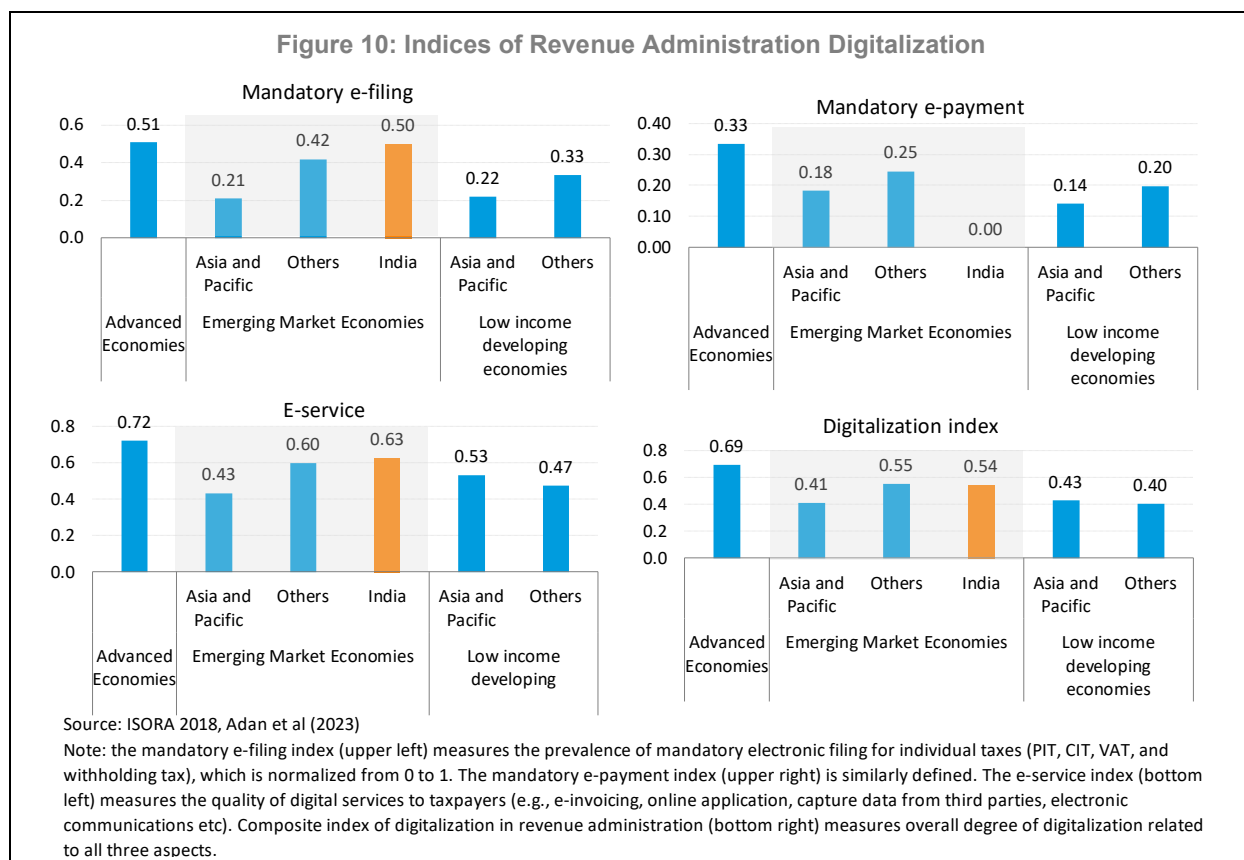| Table 3. Coverage of Households under the PMGKY Scheme (Share of All Households)					
	All	**Rural**	**Urban**	**Poor**	**Non-Poor**
Food only	40	38	43	42	39
Cash only	6	7	4	6	6
Food and Cash	34	40	22	40	32
At least one benefit (Food or Cash)	80	85	69	87	76

Source: World Bank, 2021

Revenue gains

Cross-country analysis suggests that digitalization can improve the efficiency of revenue collection. India's efforts in modernizing tax administration, including through DPIs, brings it close to the digitalization frontier. For the median low-income developing country, moving towards the frontier could increase VAT revenue by 0.9 percent of GDP, PIT revenue by 0.2 percent of GDP and CIT revenue by 0.6 percent of GDP. For the median emerging market economy VAT, PIT and CIT revenue could increase by 0.7, 0.1 and 0.4 percent of GDP, respectively (Kitsios and Mukherjee, 2022). Similarly, online filing and payments generally contribute to reducing compliance costs and increasing tax revenue collection especially for VAT. Countries that make e-filing and e-payment mandatory collect about 4-5 percent of GDP higher tax revenues on average, suggesting larger scope of revenue mobilization for many countries including India (Mengistu and Nose, forthcoming). There remain large gaps in utilizing digital tools in revenue administration across countries. In this context, the efficient utilization of digitized information such as e-auditing (often deploying data analytics and machine learning) as part of tax administration, as India is implementing, is found to significantly increase revenue mobilization in many EMDEs. The analysis also highlights that the revenue gains from digitalization critically hinges on enhanced digital connectivity and sufficient staffing of skilled tax officials.[17]

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[17] The analysis uses the International Survey on Revenue Administration (ISORA) and the IMF's Tax Administration Diagnostic Assessment Tool (TADAT) datasets to measure digitalization in revenue administration (see Nose and Mengistu (forthcoming) for details on the estimation method and results).

Figure 10: Indices of Revenue Administration Digitalization

Source: ISORA 2018, Adan et al (2023)

Note: the mandatory e-filing index (upper left) measures the prevalence of mandatory electronic filing for individual taxes (PIT, CIT, VAT, and withholding tax), which is normalized from 0 to 1. The mandatory e-payment index (upper right) is similarly defined. The e-service index (bottom left) measures the quality of digital services to taxpayers (e.g., e-invoicing, online application, capture data from third parties, electronic communications etc). Composite index of digitalization in revenue administration (bottom right) measures overall degree of digitalization related to all three aspects.

Fiscal operations efficiency and transparency

DPI initiatives have enabled PFMS to play a central role in improving government cash management. The digitalization initiatives in the public sector enabled through the adoption of DPI have allowed the PFMS to play a central role in improving government cash management. By adopting e-payments, the cash position of the treasury could be established faster and more precisely, strengthening the government's Treasury Single Account (TSA). The entire ecosystem of digital payments in India, including UPI and the adoption of DBT, has supported a real time exchange of debit and credit transaction information, with a unique identifier for reconciliation between PFMS and financial sector. These capabilities provide scope to move towards fully automating payment workflows and bank reconciliation, which is key to establishing treasury cash positions.

PFMS has been supporting significant improvements in cash management and the TSA operation. The MoF's digital solutions to support public finance have supported the implementation of the Single Nodal Agency (SNA) Dashboard of PFMS during 2022. The SNA model is a new mechanism in the PFMS for distributing the centrally sponsored schemes (CSS)-related amount to states. Under this model, every state should identify and designate a SNA for every CSS scheme, and all the resources for that scheme will flow through that SNA's bank account. The MoF can track funds released from the central treasury to state treasuries and departments and right down to the final beneficiary. Based on this information, the Union treasury will transfer funds only when the previous transfer was executed avoiding the presence of idle resources at the CSS' bank accounts. The MoF saved around USD 1.2 billion as a result of SNA adoption during FY 2021/22. In addition, the PFMS functionalities, in combination with the capabilities of the e-payments ecosystem, will support the configuration of zero balance accounts in the banking system for all the funds of the Union transfer to the states, planned for

March 2023. This situation will provide real-time knowledge of the Union cash position, allowing a more active cash management ensuring the resources are available on time to meet the payment and transfer obligations when they fall due, avoiding the generation of shortages or an unutilized surplus. During FY2021/22 the Government of India estimated a saving of about USD 1.2 billion in interest cost due to introduction of TSA.

Improvements in fiscal transparency were achieved by utilizing functionalities enabled by DPI initiatives as a part of the public finance digital solutions. For example, in the case of PM-KISAN program, a minimum income support scheme for farmers, the beneficiaries can receive the payments through Aadhaar banks accounts, and they can go online and check the status of their payments in the PFMS website. The PFMS alerts users through text messages on registered mobile numbers. Every beneficiary can access and print a comprehensive report on the funds transferred under approximately 8,000 government schemes at federal and state level channeled via the DBT, which also takes advantage of the DPI platforms.

Development outcomes

Digitalization of government services can improve health and education outcomes. The provision of e-government services along with high quality telecommunications infrastructure is associated with efficiency in health spending, which translates to higher life expectancy and lower infant mortality. India's investments in DPI places it close to the government digitalization frontier. In contrast, Bangladesh, a country with a similar income level to India is further away from the frontier. For these emerging market economies, moving towards the frontier can increase life expectancy by 0.6 and lower infant mortality by 0.8 percentage points, while for low-income developing economies it can increase life expectancy by 0.8 and lower infant mortality by 4.2 percentage points (Kitsios and Mukherjee, 2022). Similarly, digitalization can improve the efficiency of education spending, and increase gross enrollment rates for tertiary, upper secondary and secondary education. For emerging market economies, and low-income developing economies moving towards the frontier can help lift tertiary enrollment rates to 44 and 12 percent, respectively (Kitsios and Mukherjee, 2022).
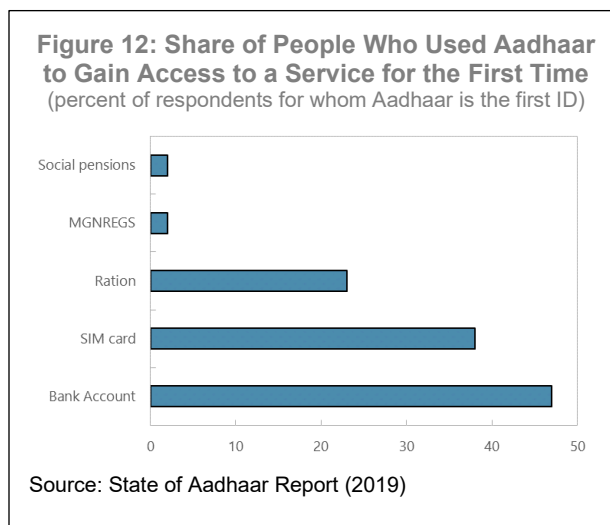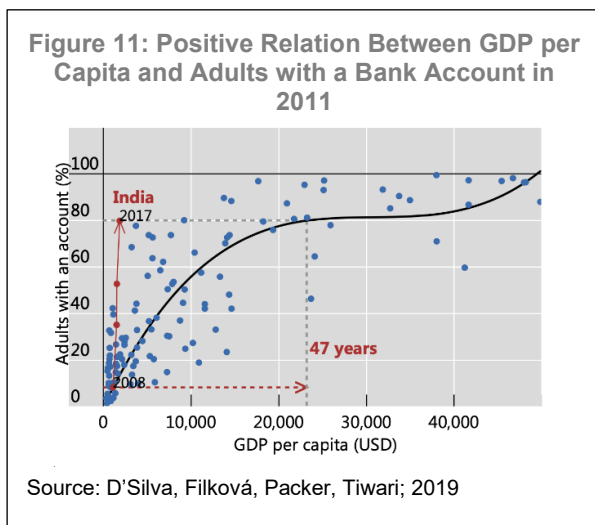
Financial inclusion

Digital ID lowered the cost barrier to providing financial services. Aadhar based e-KYC simplifies the process for accessing financial services. According to some estimates, banks that use e-KYC lowered their cost of compliance from Rs 1,000 (USD 12) to Rs 5.(US 6 cents) (Hariharan, 2016)[18]. The decrease in costs made lower income clients more attractive to service and generated profits to develop new products

Adoption of Aadhaar and digital payment solutions and enhanced competition has boosted financial inclusion. Aadhaar was the first ID for a minority and almost half of these persons used Aadhaar to open a bank account for the first time (Figure 12). Overall digital payments increased three-fold in volume and by 50 percent in value from June 2020 to June 2022.[19] New FinTech service providers are also providing alternative solutions to that of traditional banking services, some of which are newly available and targeted to lower income and rural segments of the population. It would have taken 47 years for 80% of adults to have a bank

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[18] This is in line with other estimates on the fall in the cost of opening bank accounts, see BIS Working Paper 986: Platform-based business models and financial inclusion

[19] Digital payments include RTGS (customer and inter-bank transactions), retail electronic clearing – NEFT, IMPS, NACH (credit, debit and APBS), card payment transactions (excl. cash withdrawal), PPI payment transactions (excl. cash withdrawal), UPI (including BHIM & USSD), BHIM Aadhaar Pay, AePS fund transfer and NETC (linked to bank accounts)

account if India had relied on traditional means (D'Silva, Filková, Packer, Tiwari; 2019)[20]. Indian fintech have made especially rapid gains in payments enabled by UPI. For instance, mobile money accounts per 1,000 adults quadrupled from 2017 to 2021.[21]

Figure 11: Positive Relation Between GDP per Capita and Adults with a Bank Account in 2011

Source: D'Silva, Filková, Packer, Tiwari; 2019

Figure 12: Share of People Who Used Aadhaar to Gain Access to a Service for the First Time
(percent of respondents for whom Aadhaar is the first ID)

Source: State of Aadhaar Report (2019)

The AA Framework allowed a wider segment of the population to access financial services by lowering servicing costs and enhancing the availability of financial data. Electronic submission of financial data through the AA Framework significantly reduced onboarding times and costs. In part, the AA Framework has reduced fraud and loan application scams as the financial data required for loan applications are standardized, and less prone to modifications. More than 4.5 million individuals and companies have benefited from easier access to financial services, through the AA Framework since it was first introduced in August 2021, and adoption is increasing rapidly, with 0.5 million new linked accounts in the first quarter of 2023 . By making loans more accessible, streamlining procedures, and lowering prices, OCEN could further improve access to working capital for MSMEs, including farmers and small shop owners.[22]

Some challenges remain. About a fifth of the population remains unbanked. Major barriers include low digital and financial literacy, low-income levels, connectivity, and digital infrastructure availability. However, digital solutions, such as extending UPI to feature phone usage, a framework for offline payments, and simpler interfaces such as voice-based digital payments may a go a long way to address these challenges.[23] In addition, payments infrastructure allows the government to easily disburse grants or subsidies, that also improves financial inclusion.

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[20] The authors estimated the relationship of GDP per capita and financial inclusion based on 2011 panel data. Using this relationship and projections for GDP and population growth, it would have taken until 2055 for India to achieve 80% of adults with an account. Instead, using the DPI and supporting policies, India was able to achieve this coverage in 2017.

[21] IMF's financial access stats.

[22] The MSME sector alone contributes ~30% to the Indian GDP, as well as 45% to India's manufacturing output and 48% to exports.

Taking it forward

While India Stack has been transformational, challenges need to be resolved to further maximize its potential. These include closing the digital divide and providing better data protection. India Stack continues to be used as a springboard for innovation, and the principles underlying its development are now applied to a wide range of areas. This section highlights new initiatives in health, e-commerce, and payments, and provides recommendations of areas where DPIs can be exploited to support inclusive growth, such as modernizing social protection.

Closing the Digital Divide

Despite significant progress, digital literacy remains low in India, and represents a barrier to engaging with DPI-based solutions. For example, while there has been an exponential increase in UPI-based payments, only 35 percent of persons aged 15 and over have made or received a digital payment, indicating that the use of digital solutions is concentrated within select segments of the population. Digital literacy is "the ability of individuals and communities to understand and use digital technologies for meaningful actions within life situations" (NIELIT, 2022) and so, it requires individuals to be able to use computers, tablets, or smartphones and access the internet. Mothkoor and Mumtaz (2021) estimate that only 38 percent of households in India have at least one person that is digitally literate based on the 2017-18 National Sample Survey data.

The digital divide appears along familiar gender, geographic and income lines. Digital literacy is more than twice as high in urban areas (61 percent) than in rural areas (25 percent). A mere 14.9 percent of rural households have internet access, compared to 42 percent among urban households. Women are significantly more likely to be digitally illiterate, particularly among low-income groups. While 43.5 percent of urban men know how to use the internet, only 30.1 percent of urban women and 8.5 percent of rural women do. More broadly, only 53.9 percent of women have a mobile phone for their own use and among them, 29.5 percent are not able to read SMS messages (MHFW, 2022). Digital literacy is low for older and poorer individuals. While two thirds of men aged 20-24 have ever used the internet, only a third of those aged 45-49 have. The decline is even more pronounced among women. Half of women aged 20-24 have ever used the internet, whereas only 13 percent of those aged 45-49 ever have. Digital literacy is quite high among the richest households with 78 percent of men and 69 percent of women having ever used the internet. However, only a quarter of men and barely a tenth of women in the poorest households have ever used the internet. There is also marked heterogeneity across the country, with more than half of the households enjoying internet access in Delhi (55.7 percent), Kerala (51.3 percent), and Himachal Pradesh (51.5 percent) compared to only a tenth of households in Odisha.

The Indian authorities have launched several initiatives to address the challenge of low digital literacy. The National Digital Literacy Mission aims to train at least one person per household with the basics of digital literacy, use of internet, and access of government services (NIELIT, 2022). Almost 57 million students had completed training and 42 million students were certified as digitally literate as of December 2022 (PMGDISHA, 2022). Another important mechanism for closing the digital gap is the role of public access outlets set up as intermediaries to support final users in accessing government services. Sharma and Mishra (2017) document that users do take advantage of these outlets when the person providing the service at the outlet exhibits

empathy, assurance, and responsiveness and when the outlets are reliable and endowed with adequate facilities (e.g., seating space, drinking water). RBI efforts to raise digital literacy include the Electronic Banking Awareness and Training (eBAAT) programme, the Kehta Hai awareness campaign on financial literacy, and the 24x7 DigiSaathi helpline to address queries on the payment system.

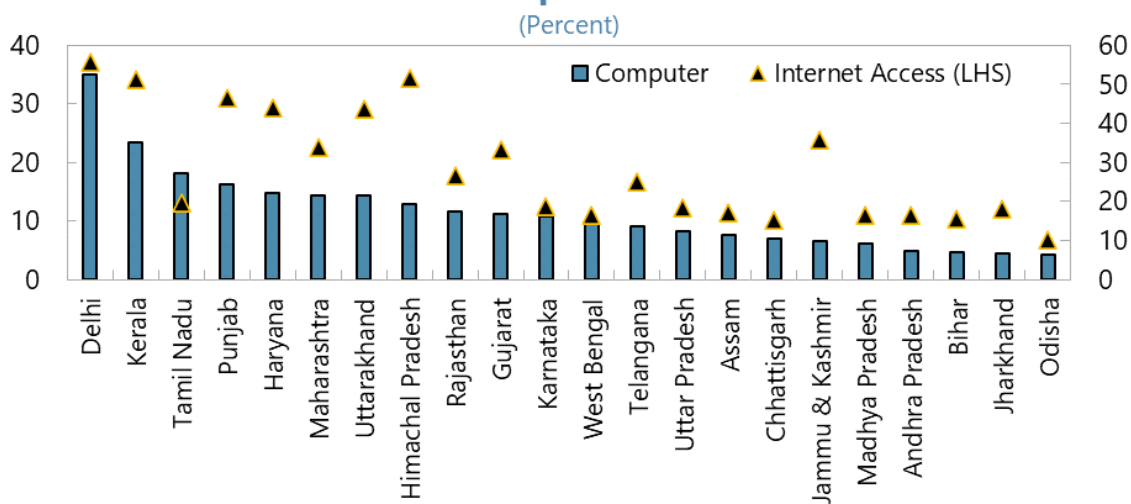**Figure 13: The digital divide in India**
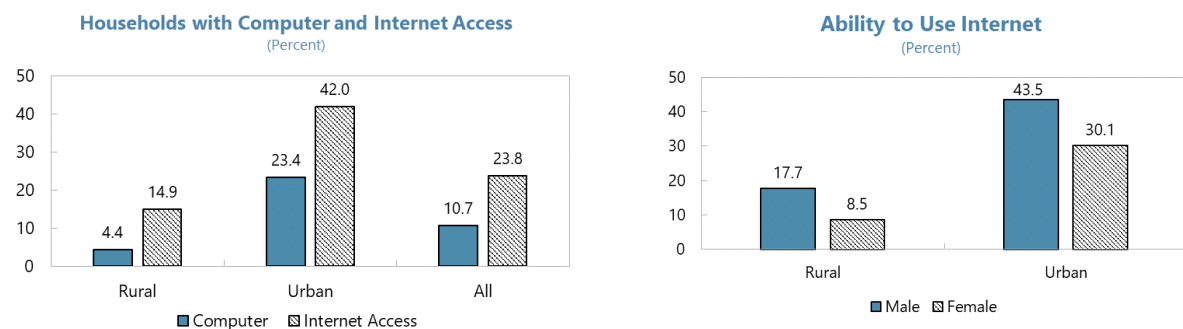
Source: NSS 75th Round (2017-18) based on NSO (2019).
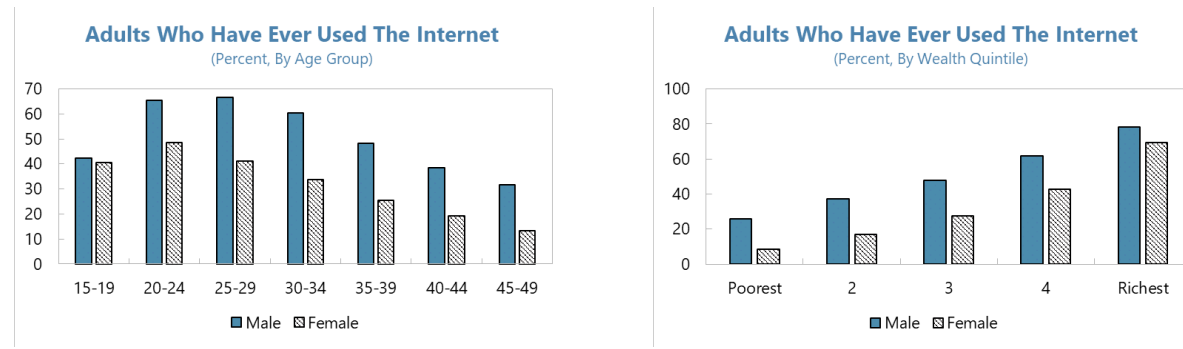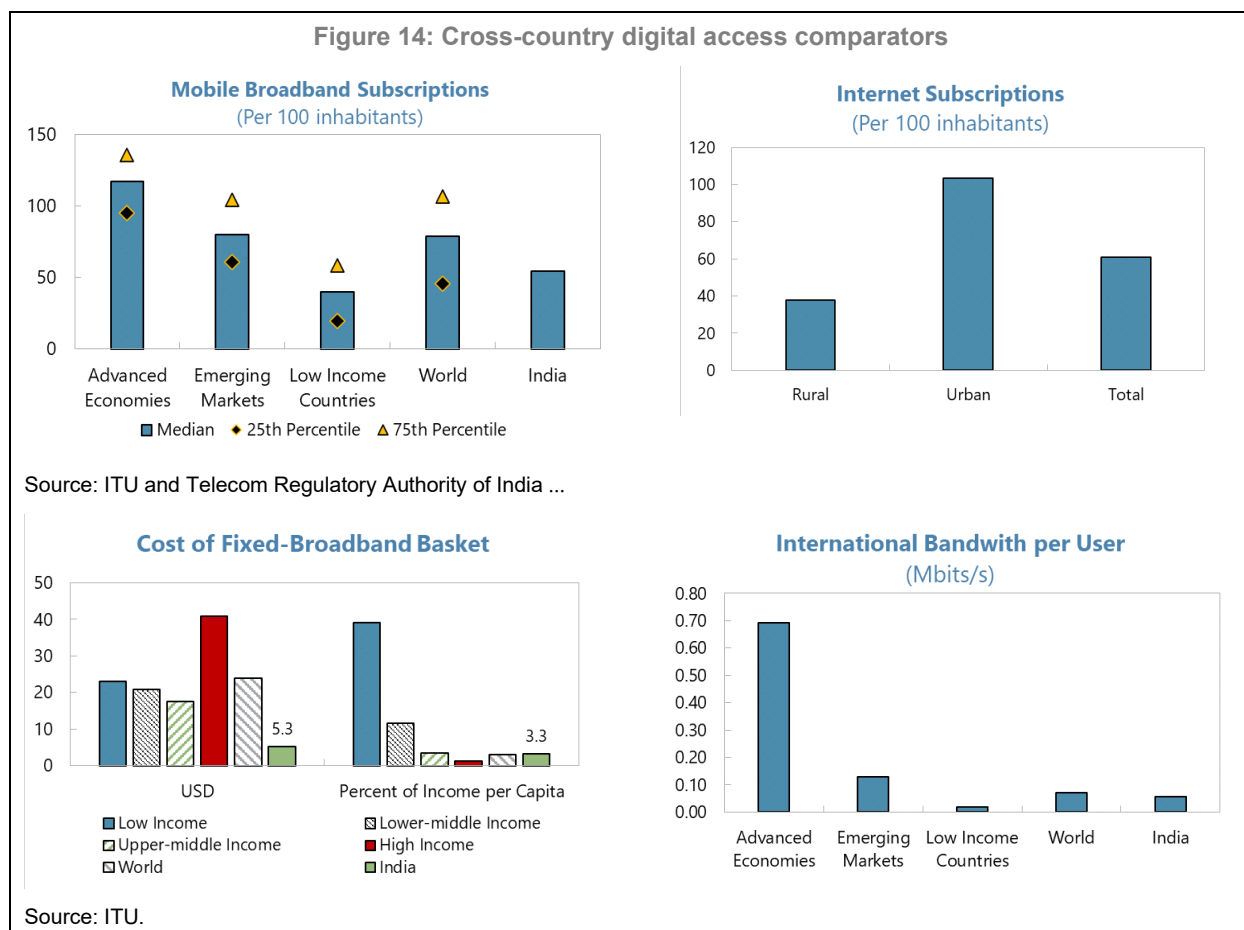

Source: NFHS-5 (2019-21) based on MHFW (2022)

Source: NSS 75th Round based on NSO (2019).

Digital access in India remains limited. India has 54 mobile broadband subscriptions per 100 inhabitants, which is below the global median of 79 and the median for emerging market economies of 80. There are also wide inequalities of access within the country. Internet subscriptions are almost three times larger in urban areas than in rural areas. There are 103 internet subscriptions per 100 inhabitants in urban areas, but only 38 in rural areas. While rising, smartphone penetration is low in India. In 2021, smartphone penetration was estimated at 35 percent compared to 62 percent in Indonesia and 55 percent in Brazil (Statista, 2022). The share of households with a smartphone in rural areas more than doubled in just four years, rising from 36 percent in 2018 to 74.8 percent in 2022 (ASER, 2023). While this is remarkable progress, still a quarter of households do not have access to a smartphone. The authorities are addressing the challenge of low smartphone penetration by providing access to feature phones, which can connect to the internet although they do not have all the capabilities of a smartphone. For instance, in March 2022 the Reserve Bank of India launched UPI for feature phones benefiting 400 million users (RBI, 2022).

Mobile data is cheap in India, but international bandwidth per user is low. A mobile data and voice basket (including 70 min + 20 SMS + 500 MB) costs USD 1.8 in India compared to a median of USD 11.5 around the world and USD 7.6 among lower middle-income peers. Normalized by income levels, the basket represents 1.1 percent of income per capita in India, roughly half the median cost around the world and a quarter of the cost in lower middle-income countries. However, international bandwidth (that is, the maximum rate of data transmission between a country and the rest of the world) is low when normalized by the number of internet users. In India, the international bandwidth per user is 0.06 Mbits/s, slightly below the global median of 0.07 but only half of the median for emerging market economies.[24]

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[24] The authorities aspire to a vision of visual broadband for all by 2025, defined as two-way 20-megabits-per-second (Mbps) data transmission speed per household (MEIT, 2019).

Figure 14: Cross-country digital access comparators

Source: ITU and Telecom Regulatory Authority of India ...

Source: ITU.

Data Protection

Cyber risk is serious and costly. It has been reported that more than 80 million Indian users were affected by data breaches in 2021 (Business Today, 2021). Data breaches in 2021 included Air India, Domino's, Facebook, Mobikwik, and Upstox exposing users' names, phone numbers, and even bank account, passport, and Aadhaar data (Internet Freedom Foundation, 2021). IBM estimates that the average cost of a data breach in 2021 in India amounted to USD2.2 million (IBM, 2021). For comparison, the average cost around the world was estimated at USD4.24 million per incident. For users, the experience of fraud can weaken trust and delay transition to digital channels (Jain and others, 2021).

Comprehensive data protection legislation is still missing in India, placing the privacy and other digital rights of users at risk. In 2017, the Indian Supreme Court ruled that privacy is a fundamental right and asked the government to implement a robust regime for data protection (NPR, 2017). Since then, several iterations of relevant legislation have been drafted and have undergone public debate. Most recently, a draft Digital Personal Data Protection Bill was released for public consultation on November 18, 2022, and a draft Digital India Bill is being developed. The Indian authorities aim to strike an appropriate balance between protecting citizen rights and fostering innovation (Business Standard, 2022). However, commentators have noted that the draft Digital Personal Data Protection Bill provides excessive exemptions benefiting government authorities, does not attempt to categorize data implying that all data would be protected equally which could be costly, and

leaves too many specifics to be determined in the regulations (Goyal, 2022; Gupta, 2022; Koppikar, 2022; Mishra, 2022; Mukherjee, 2022). A robust data protection framework is essential to protect citizens' privacy, prevent companies and governments from indiscriminately collecting data, and holding companies and governments accountable for data breaches to incentivize appropriate data handling and adequate investments in cybersecurity.[25]

Modernizing social protection

The DPI can help support efforts to make social assistance more resilient and adaptable. India's economic growth in the last decade and the rise of shocks such as the pandemic, changed India's social protection needs and risk groups that could fall into poverty in the event of an adverse shock. The future social safety net should allow for more flexibility in reaching (potential) vulnerable groups (e.g., migrants, informal workers and the urban poor) (World Bank 2021). The DBT currently does not have access to socio-economic data and is not able to target households based on these data. The unique Aadhaar identifier could enable easier data exchange between various scheme holders [26]. The availability of socio-economic data is key to reach intended beneficiaries and data exchange would allow for complementary information. Targeting is key to contain fiscal costs and ensure sustainable fiscal financing. While the current schemes reached a large group of households during the pandemic, there is significant room to identify (new) groups as studies show that the pandemic response excluded about half of all women (Pande et al 2020). Experience in other countries has shown that digital technologies can be deployed to use alternative targeting methods and allow for mass registration (World Bank, 2022).

It is important to address limits of the system to help prevent the exclusion of genuine beneficiaries.
Exclusion errors can occur in several ways. Initial experiences with Aadhaar showed that exclusion errors occurred because of fingerprint recognition problems and limited internet connectivity. A 2019 survey found that 2.5 percent of respondents experienced exclusion from a welfare service because of problems with Aadhaar (Figure 15). It is crucial to establish appropriate digital network such as power, internet and mobile connectivity, correct Aadhaar linking and alternative methods of verification (such as passwords) when biometric verifications fail. As a response to these events, the Supreme Court has ruled in the past that Aadhaar

Figure 15: Share of people who have been excluded from services
(percent of survey respondents)

Source: State of Aadhaar Report (2019)

can only be mandatory when citizens owe funds to the government (such as tax payments) but not in the distribution of social benefits. Exclusion errors could also arise when households do not have sufficient access to digital tools. Finally, exclusion errors could arise from insufficient digital adaptation. As noted earlier, it is key to invest in households' digital literacy and skills to use digital tools.

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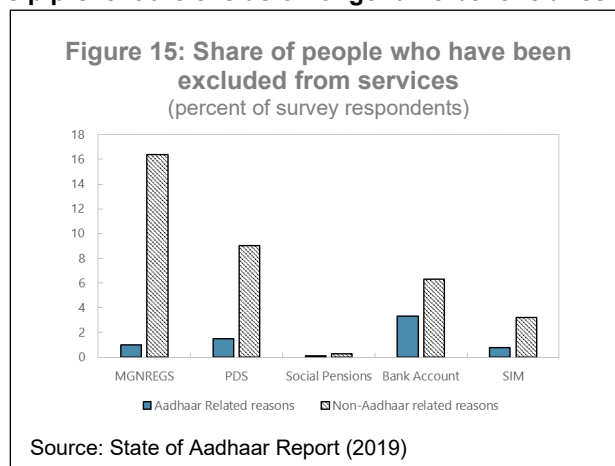
[25] Guidelines issued by the RBI in 2018 mandate the storage in India of payment data (RBI, 2018).
[26] Currently, data protection and privacy laws in India do not allow States to exchange such type of data.

Fiscal Transparency and Financial Reporting

India should improve the timeliness, quality, and coverage of the government budgetary and financial reports. Currently, the government of India does not compile and disseminate Government Financial Statistics (GFS) and Public Sector Debt Statistics (PSDS) for general government on a high frequency basis. As part of the G-20 Data Gap Initiative (DGI), India had agreed to begin compiling and disseminating high-frequency GFS and PSDS for a modified general government (budgetary central government (BCG) and state governments) by 2021. Despite the activities developed, some of them with IMF support [27], this challenge is still pending. Combined Union and State financial accounts are produced by MOF two years after the end of the fiscal year but are not audited statements. Financial reporting is on a cash basis with elements of accrual accounting, as required by CGA and/or recommended by the Finance Commission. Limited accrual information is available, mostly debt and loans, and some financial assets are included (but not regularly updated).

Both Union government and state governments should incorporate user-friendly information and narratives alongside or ahead of their budgets and financial statements. While states are starting to recognize the value of a fiscal strategy paper issued in advance on the budget, this is lacking at the Union level.

The adoption of a specific DPI data layer focused on government financial reporting will be key element to produce timely, relevant and reliable fiscal reports. The Union and state governments use multiple financial information solutions, which requires well designed interfaces and clear standards to consolidate. One experience that could provide important lessons in this subject is a Brazil National Treasury Secretary platform called Sistema de Informações Contábeis e Fiscais do Setor Público Brasileiro (SICONFI). SICONFI is a platform developed to receive financial and accounting information from 5,570 municipalities, 26 states, the Federal District, and the Union. The platform is focuses on integrating budget, asset, and analytical accounting to create a modern public accounting system. SICONFI uses the XBRL standard, designed for business and financial data transmission, to store and transport data. The main goal of SICONFI is to provide accurate, reliable, and timely information to public stakeholders and assist policy makers and senior level official in controlling the financial flows across different administrative instances. Considering the advances in the public finance digital solutions in India, plus the benefits already mentioned of the DPI approach, India has a great opportunity to improve the government fiscal reports.

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[27] During fiscal years 2019 and 2020, IMF's South Asia Regional Training and Technical Assistance Center (SARTTAC) began assisting India by providing government financial statistics training at the regional level and technical assistance at the national level on developing a strategy for meeting DGI requirements. In June 2020 the two first virtual workshops by SARTTAC were held with CGA officials from around the country to: (1) refresh their GFS/PSDS knowledge; (2) assess officials' efforts to apply the knowledge gained previously in translating Indian states' fiscal statistics into the GFSM 2014 framework; and (3) set the stage for a concluding round of training. In December 2021, five workshops were delivered and were anticipated to establish the translation of Indian State accounting data into the GFS framework. (Update and completion of concordance tables) It was anticipated the resulting data could be consolidated to provide annual fiscal statistics for India to meet international standards that can be disseminated as appropriate. No activity has taken place since.

New Initiatives

E-commerce

The Open Network for Digital Commerce (ONDC) is a public private partnership providing an alternative to the traditional siloed approach of existing e-commerce platforms. The purpose of this initiative is to deepen e-commerce in India, bring digitization and formalization to millions of small retail shops, shorten supply chains, and increase access to forward markets for small producers. With the ONDC, buyers and sellers are able to access one another regardless of the platform used by each, similar to the principles underlying the UPI. The provision of logistics (e.g., delivery services) and technology services (e.g., development of digital catalogues) are also open to multiple providers. The platform allows greater competition from unbundling each stage, expanding consumers' choices whilst still providing a user-friendly shopping experience. The pilot for ONDC launched in 2022 in select cities.

Health

The Ayushman Bharat Digital Mission aims to improve the efficiency and accessibility of health services. The government is building a digital backbone to connect the disparate systems in the health sector and make them integrated, interoperable and efficient. The ecosystem includes a unique health ID for individuals, a health professionals registry and a health facilities registry. These support the creation of an electronic medical record for an individual which includes data across multiple health facilities. This interoperable record can be shared, at the individual's consent, enabling better access for health professionals to a patient's medical history and enables patients to seek better care. In early March 2023, there were over 338 million unique IDs, nearly 61 million linked health records, 200 thousand health facilities and over 150 thousand health providers registered. The ID can also be used to link benefits from public health programs and insurance schemes to the individual. The next step is to automate the settlement of insurance claims. This will allow for much faster and smoother settlement of health insurance claims, removing a major source of uncertainty and anxiety for patients. It will also make apparent which providers accept which payers. Work is ongoing on the Unified Health Interface, an open protocol that would enable the provision of digital health services (e.g., appointment booking and teleconsultation). The UHI is based on UPI and allows users to access any health service provider in the country from an app of their choice. This is expected to create a thriving & competitive private ecosystem of health service providers

Extension of payment solutions and interoperability

The Indian Payments Vision 2025 calls for extending the geographical reach of services.[28] India has extended payment products, such as UPI and RuPay cards abroad.[29] The approach is to broaden merchant acceptance outside of India, starting by catering to Indian travelers. Similarly, the hope is to facilitate remittances by partnering with money transfer operators, PSPs, and banks in other countries. Finally, UPI services or UPI technology could be offered to central banks abroad. Seamless interoperability across payment systems, however, requires harmonization of legal and technological frameworks, which is complex and time consuming.

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[28] Payment Vision 2025 was approved in June 2022 by the RBI, with the core theme: "E-payments for Everyone, Everywhere, Everytime"

[29] For example, QR code-based merchant payments using UPI are facilitated in other countries, Bhutan, Singapore, UAE

CBDC

The potential of CBDC is actively being researched in India. Despite a well-developed and innovative payment infrastructure, India is actively exploring the potential of retail and wholesale CBDC, which may bring additional benefits including through parallel rails potentially more compatible with tokenized financial assets or money. In addition, interoperability with other countries' payment systems could be easier to establish, by the simple virtue of starting with a blank slate. India has been running CBDC pilots since November 2022. The project is motivated by various potential benefits including cost-savings associated with physical cash management, compatibility with a "less-cash" economy, and financial inclusion.

Interoperability and co-existence with current payment infrastructure were defined as a key feature of the CBDC project. Achieving interoperability with existing payment infrastructure is one of the potential use cases and will have to consider multiple factors that are under examination. CBDC will leverage the current payments infrastructure, as well as messaging and data models. The goal is to ensure a seamless interoperability with existing payment options and to facilitate CBDC adoption.[30]

CBDC may also enhance cross-border payments. India is the world's largest recipient of remittances, receiving $87 billion in 2021. Compared to highly efficient domestic payments, cross-border payments are costlier, slower, more opaque, and less accessible. CBDC could improve cross-border payments to the extent it begins with a blank slate and could benefit from new infrastructure such as platforms to facilitate the exchange of foreign currencies. However, CBDCs would have to be interoperable across borders, and relevant infrastructure must still be developed.

Keys to success: lessons from India

India's journey in developing a world-class digital public infrastructure highlights useful lessons for other countries embarking on their own digital transformation. Perhaps the most powerful being the underlying principles guiding India Stack's development: a foundational building blocks approach, and a focus on supporting the ecosystem. These principles drove design decisions such as: interoperability, fostering competition, and minimalist design. It also guided strategic decisions to have the government play a catalytic role with strong private sector involvement. Importantly, institutional structures were put in place to ensure that the operation and maintenance of the infrastructure would be shielded from the political cycle.

India recognized the importance of Information Technology (IT) in the development of the identity layer. Before Aadhaar, India had many identity cards and databases (e.g., PAN tax ID, ration cards), however none had universal coverage, promise of uniqueness and the ability to handle a billion-plus citizens. It was common knowledge that technology would be crucial to designing such an identity system that would provide scale, uniqueness, and robustness at an affordable cost. To tackle the design of building a massive biometric identity database, the government appointed a successful IT entrepreneur as its founding chairman; signaling its commitment to using technology to solve the policy problem and enabled UIDAI to hire better and more

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[30] [Reserve Bank of India - Reports (rbi.org.in)](rbi.org.in)

relevant talent for the task.[31] [32] The experience and challenges in rolling out the tax ID provided important lessons for Aadhaar's rollout (e.g., utilizing a novel PPP to speed up enrollments).

The digital building block approach involves unbundling the elements of the solution to a set of problems and identifying a common core. For example, in the India Stack, Aadhaar removes identification from entitlement and UPI removes payment address from payment (Mukherjee and Maruwada, 2021). This modular approach fosters innovation, allowing each building block to address multiple problems, including for use cases not envisaged by the initial developer. Focusing on the problem's core also allows each building block to be used at population scale. For a large and diverse country such as India, a building block approach provides those closer to the problem with the basic tools to create tailored solutions. In the case of Aadhaar, the unbundling as well as the minimal information collected (name, age, gender, address, biometrics) enabled its rollout at speed and scale. In contrast, other countries have hit stumbling blocks with their digital ID rollout when these IDs convey an entitlement, such as citizenship.

A focus on supporting a vibrant ecosystem implies the need for interoperability and a competition-focused design. For India, interoperability was supported through open standards, allowing anyone to utilize the functionality provided by India Stack. Not only does this increase interoperability, but it can lower costs, foster competition, provide an opportunity to tailor solutions to the local context and enhance flexibility to adapt to changing needs. Within the design of India Stack, particular care is given to encouraging competition and removing silos. For example, UPI sidestepped existing bottlenecks and incumbent interests. The development of the ecosystem was also supported by strong stakeholder engagement, enabling the delivery of user-centric solutions that are fit for purpose.

The government further promoted the use of technology as "utilities". Two committees further shaped India's digitalization journey. The first is the Technical Advisory Group for Unique Projects committee whose objective was to investigate the use of IT for designing an effective tax administration and financial governance architecture (Ministry of Finance, 2010). The second was the committee on Electronic Toll collection that would form the basis of FasTag (Ministry of Road Transport and Highways, 2010). A key recommendation of the committees is the creation of institutions called "National Information Utilities" (NIUs) who will be responsible for the technology related aspects of digitalization projects designed by the government. (Press Information Bureau, 2011). These NIUs are 'not-for-profit private companies with a public purpose' such as NPCI. This allows them to address the various human resources and procurement challenges that often plague large government projects. The committee also emphasized the use of Open Protocols, and Open Source systems.[33] The establishment of NIUs is one strategy to strike a balance between curbing monopoly rents and providing these services effectively and efficiently.

Dedicated agencies and corporations were created to operate and maintain the infrastructure, ensuring continuity of DPI operations. The UIDAI continues to be responsible for the maintenance of Aadhaar. Notably, while political support is needed for all major reforms, it is particularly important for new initiatives in

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[31] In January 2009, the UIDAI was initially set up by the Government of India as an attached office under the Planning Commission via a notification in the Gazette of India. In July 2016, UIDAI became a statutory authority and government department under the Aadhaar Act (2016)

[32] Nandan Nilekani, previously CEO of Infosys, was the inaugural chairman of UIDAI. Infosys was largely seen as one of the most successful examples of Indian IT Services companies and was the first Indian company to be listed on NASDAQ

[33] This would later be formalized into the Policy on Adoption of Open Source Software for GoI and Framework for adoption of OSS in eGovernance Applications in 2015 (Department of Electronics & Information Technology, 2015)

IDs; UIDAI has spanned two administrations thus far. Political support coalesced around common issues of tackling corruption and reaping efficiency gains. The UPI is operated by NPCI (see Box 2). A subsidiary of the RBI, Reserve Bank Information Technology Private Limited (ReBIT), framed the core technical specifications for the participants of the AA ecosystem and Sahamati is the industry alliance helping onboard new players to the ecosystem.

Box 2: NPCI's Positioning and Funding

The NPCI has focused on providing infrastructure, while allowing the private sector to innovate and serve as the main point of contact with end-users. The NPCI addressed fragmentation in payment systems by unifying the multiple payment systems, clearing houses, and networks under its umbrella organization. The public sector provided digital public infrastructure, and strengthened payment system regulations, while the private sector has focused on developing innovations and onboarding consumers. Government can further promote the use of DPI, by promoting competition among private sector service providers.

Government subsidies and reinvestment of profit have helped provide a low-cost and cutting-edge public infrastructure. Unlike its newly established co-entity NPCI International, NPCI itself is a not-for-profit organization. This allows services such as UPI to be offered at low cost to consumers. Additionally, the Indian government promotes UPI-based merchant payments and incentivizes financial sector stakeholders, including banks, to provide payment services at low cost. For example, to encourage the use of digital payments, formalize the economy, increase access to finance and reduce the usage of cash, the government removed all fees for UPI transactions. The Ministry of Finance also pays a subsidy to banks in lieu of the fees foregone. The budgeted allocation for promoting digital payments (including other initiatives) for FY2023/24 is USD 188 million. The hope is that once usage is widespread, the government will be able to reduce subsidies.

The government acted as an anchor client, utilizing the infrastructure to make transfers to beneficiaries of social support programs, providing an impetus to adopt the technology. DPI is an example of a two-sided market where the value of the platform increases for both participants as the numbers on each side increases. For example, the incentive for individuals to sign up for a digital ID increase with the number of service providers that will utilize the ID. Similarly, providers will undertake the investment to incorporate a digital ID into their systems if they are confident that many customers would have the ID. The same incentives hold for payments systems, and the high degree of interoperability of UPI magnifies the incentive to adopt, while lowering the costs of adoption for individuals. By using Aadhaar and Aadhaar linked accounts to provide Direct Benefit Transfers, the government encouraged take up by individuals and gave service providers the comfort of access to a large client base. This strategy was also used in Thailand, where the government used the Pao Tang mobile wallet application, and associated infrastructure, to implement pandemic relief measures (OECD, 2022).
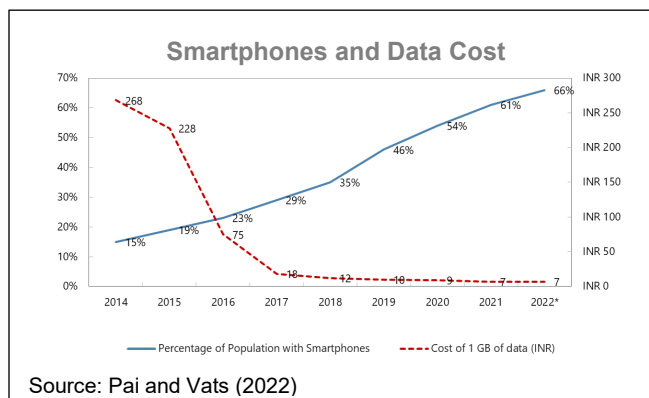
The vibrant startup ecosystem and broader private sector has been a key factor to India's growth in use of DPIs. The high adoption of UPI is in a large part due to the investments made by payment apps such as PhonePe, Google Pay, PayTM and others who attracted a large merchant base and spread customer awareness. These companies have emerged in India partly due to its up-and-coming technology startup ecosystem. Payments is a high-frequency use case and thus building a payments app allows these companies to build a financial app that is used every day by millions of people. This opens up many avenues for cross-selling of other adjacent financial services or ecommerce products. Even the disruptive launch of Reliance Jio, a mobile network operator, was enabled by the adoption of eKYC (see Box 3). Since a KYC

check is mandatory by regulation before issuing any telephone connection in India, telecom operators would often spend over 48 hours in verifying a customer's identity, with the eKYC DPI this verification became instant.

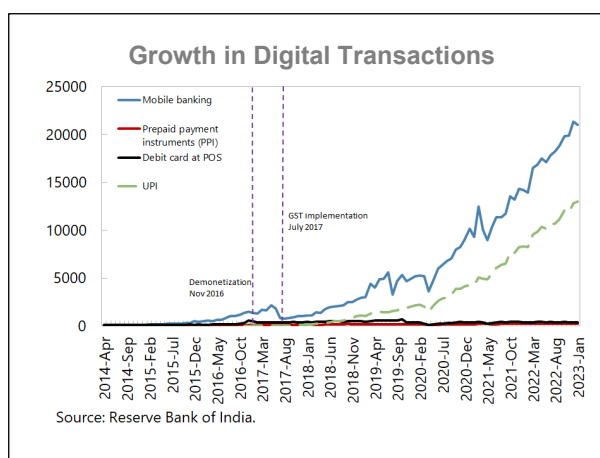**Box 3: Enabling policies and factors**

The increased penetration of smartphones and mobile data due to sound telecommunications policies leading to a competitive, open and affordable telecom market, supported the use of DPIs. Along with the broader macro-economic liberalization of India, the telecommunications sector was opened for foreign investment

in 1994. The state set up a regulator, Telecom Regulatory Authority of India (TRAI), that has maintained a largely pro-citizen approach to creating open networks such as a strong commitment to Net Neutrality. In 2016, TRAI notified the Prohibition of Discriminatory Tariffs for Data Services Regulations, which barred telecom service providers from charging differential rates for data services to protect net neutrality. Some companies wanted an exemption for "zero-rating", where they would partner with telecom companies to subsidize the cost of mobile data for data spent on their website in hopes of creating a habit of usage for their own products.

Source: Pai and Vats (2022)

Simultaneously, in 2016, the launch of Reliance Jio, a new 4G-only mobile network operator, brought high-speed internet to the whole country and crashed the cost of mobile data by 96 percent. The usage of mobile data went up by 100-fold from 154 MB/month in 2015 to 15.8 GB/month in 2021 (TRAI, 2023). This led to a growth in smartphones, and hence made reaching citizens by digital solutions built on top of DPIs more accessible to the private as well as public sectors.

Another key enabling policy is the RBI and Government of India's emphasis on financial inclusion. In 2014, the government of India launched the Pradhan Mantri Jan Dhan Yojana, which provided access to a no-frills, low-cost bank account. The scheme targeted the financially underserved, especially rural women. Under

the Jan Dhan initiative 462.5 million of bank accounts were opened in both urban as rural areas until August 2022.[34] A majority (56%) of the beneficiaries of the Jan Dhan Yojana were female. In late 2016, India enacted a demonetization policy where large currency notes were invalidated with the aim to fight tax avoidance by use of cash. While disruptive, this led to the entire country experimenting with digital means of payment such as credit cards, debit cards, mobile wallets and UPI apps. To use the full functionality of UPI, one must have a bank account. Thus, UPI could succeed only because of the increased bank account penetration bought out due to the Jan Dhan Yojana.

Source: Reserve Bank of India.

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[34] See https://www.pib.gov.in/PressReleasePage.aspx?PRID=1854909

Certain features of India's journey would be difficult to replicate elsewhere, such as the government-led development of Aadhaar, though this is not a precondition for success. The in-house development of Aadhaar, supported by private system integrators, was feasible in India due to the high level of capacity in IT within its domestic labor market. In-house development was also borne out of necessity as the cost of proprietary software at the time was prohibitive. This approach allowed India to avoid vendor lock-in and lack of interoperability but creates a need for sufficient resources and capacity to continue maintaining and developing the infrastructure. As an indication, the budget allocation for UIDAI in FY2022/23 was USD 137 million. The approach by other countries varies, for example, the banking sector led the development of the digital ID in Sweden. Avoiding vendor lock-in can also be achieved through the use of open-source software (World Bank, 2019). Open-source software is available for digital ID (e.g., MOSIP, developed in India and used in Ethiopia, Guinea, the Philippines and others), payments (e.g., Mojaloop developed by an international consortium and used in Africa and UPI[35]) and data exchange (e.g., X Road, developed in Estonia and used in Kyrgyzstan, Iceland and Japan).

There are also features arising out of India's specific context which may not be applicable for others. For example, to access the full functionality of India Stack, individuals need access to a smartphone, although other access options are available (e.g., UPI for feature phones, assisted channels). This is an outcome specific to India's context, partly due to low data costs and relatively high smartphone penetration (Table 4). That said, it is in part a symbiotic relationship; as noted earlier, India Stack enabled telecommunications companies to sign up new customers with ease, driving economies of scale. The full functionality of UPI also relies on users having access to a bank account, as it facilitates transfers between these accounts. This is feasible in India as government policies facilitated access to bank accounts for vulnerable sections of the population (See Box 4). For other countries with low adoption of smartphones and lack of access to banks, payments systems based on mobile money that can be used on a feature phone are the dominant form of digital payment (e.g. Kenya and Togo, see Box 4).[36]

Table 4: Cross-country comparison							
	Chile	**Estonia**	**India**	**Kenya**	**Singapore**	**Togo**	**Thailand**
Share of population with ID 1/	98.8%	98.6%	96.8%	90.9%	94.7%	39.8%	99.5%
GSMA mobile connectivity index	76.4	83.8	61.3	53.2	91.4	39.5	77.7
GSMA mobile subscriber penetration score	91.5	97.0	59.7	58.9	98.2	54.1	96.2
Smartphone penetration 2/	70.0%	62.0%	73.0%	46.0%	89.0%	39.0%	59.0%
Mobile data affordability (US$ per GB) 3/	0.5	1.2	0.2	0.8	0.6	12.9	0.4
GSMA network coverage score	88.7	89.3	88.9	87.3	97.4	76.5	95.9
Share of population 15+ with account at financial institution or mobile money provider	87.1%	99.4%	77.5%	79.2%	97.5%	49.6%	95.6%
Share of population 15+ made/received digital payments	84.3%	98.7%	34.9%	77.6%	94.8%	43.7%	92.0%

Sources: World Bank; World Bank, *Global Findex Database;* GSMA; Statista; and cable.co.uk.

Note: Data as of 2021. 1/ Data as of 2017. 2/ Data for Chile, Estonia (Statista), India, Kenya, Singapore and Thailand as of 2021 and Togo as of 2018. 3/ Data as of 2022.

Elements of India's success that is applicable to other countries is the focus on identifying the core problem, building a solution to address this, and then ensuring wide access for others to utilize the solution. For economic interactions in the digital age, the core issues are proving your identity; making cost-effective payments, as well as secure and convenient sharing of data. These are the primitives of the digital

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[35] While UPI is not open source, NPCI International does make it available to other countries.

[36] M-Pesa was launched in India in 2013, but was withdrawn from the market in 2019 due to stringent regulatory requirements, as RBI considered them to be a banking service, and strong incumbent competitors.

economy because they are common requirements for economic transactions across many varied scenarios (Vir and Sanghi, 2023). The experience of other countries demonstrate that each layer of India Stack is useful by itself and that there is no 'correct' sequencing; the lack of a national digital ID does not stop the development of a payments layer (e.g., Kenya). Similarly, the role of government in the provision of this infrastructure differs across countries, what is crucial is providing for interoperability.

Box 4: Country Experiences Across the Digital Transformation Spectrum.

Many countries are investing in "stacks" comprising of digital ID, payments and data exchange. Singapore and Estonia are well established, with elements similar to India's stack. In addition, Singapore and Estonia also have a whole of government data sharing platform. Other countries are in the process of developing their stacks, with certain layers (e.g., payments) more advanced than others. The degree of openness and interoperability within and between the layers also differ across countries.

Singapore added to its "stack" with the launch of the financial data exchange in 2020. The national digital ID Singpass, gives access to thousands of public and private sector services. PayNow is the digital payment solution developed by participating banks and NFIs, allowing users to transfer funds using their identity number or mobile number instantly. By leveraging local banks' PayNow and NETS e-Payment ecosystems, the government can perform instant transfers from agencies to beneficiaries. The e-payment landscape is fragmented, and work is underway by NETS to expand interoperability between various e-wallets and bank accounts. Reducing this fragmentation would encourage adoption of e-payments at hawker centers, canteens etc, where cash is still the dominant mode of payment. Singapore's Financial Data Exchange, developed under a public-private partnership, allows individuals to use their SingPass to retrieve personal financial information such as deposits, loans, insurance policies and stock holdings. This complements the existing government data exchange platform (APEX) and consented data sharing mechanism, (MyInfo).

Estonia has a high level of digitalization in public and private service delivery. Banks drove Estonia's digital payment solution, but most non-cash payments (68%) are still card based (Olt,2020). The e-ID and e-signature enables digital form of strong costumer authentication and automation in the financial sector. E-ID used technical components from Finland as a starting point but was then modified and improved for Estonia's requirements (Kaevats, 2021). Notably, Estonia's data exchange layer, X Road, is open source and also used in Finland, Kyrgyzstan, Faroe Islands, Iceland and Japan (World Bank, 2019). Similar technology based on the Estonian experience is implemented in Ukraine and Namibia (World Bank, 2019).

Kenya has a well-established digital payment solution in the form of mobile money. The mobile money platform was developed by a private telecommunications company, Safaricom. Users do not need a bank account to transfer money, but funds in the mobile wallet can be transferred into a bank account. M-pesa is the largest operator of mobile money services, but there are also alternatives (e.g. T-Kash, Airtel Money). Users within each network can make P2P transfers to other on the same network and make P2B payments with participating merchants. The services offered by mobile money providers are expanding to cover financial services e.g. savings and loans. M-Pesa is designed for use with feature phones, lowering the cost of access compared with digital money solutions which rely on a smart phone. Notably, when Safaricom began operating M-Pesa in Kenya, there was no law or regulation in the country for mobile money service providers, rather operations started based on a

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letter agreement with the Central Bank of Kenya. It was only in 2014 when, with the adoption of the National Payment Systems Regulations, that a formal legal framework for mobile money was put in place in the country. Since 2022, digital credit providers have also been licensed and regulated by the central bank. Kenya is now implementing a national digital ID.

Thailand has a set of parallel ID systems, a government data exchange layer and a well-developed payments system. The ID systems include: a National ID is based on civil registries, D.DOPA developed by the public sector (pilot phase) and NDID used within the financial sector. Thailand's State Welfare Card and National ID card is used to access services and also acts as an e-wallet; transfers are made to the e-wallet which can then be used at selected stores to purchase basic necessities. The Thailand Revenue Department is piloting the use of NDID for Personal Income Tax e-filing. The data exchange layer for sharing documents across government agencies (GDX) is operational, while an exchange layer for private sector data is currently under development (e.g., open banking). The payment infrastructure, Promptpay, developed by a consortium of banks and Vocalink (Mastercard) allows for money transfers between bank accounts using the national ID, mobile number or QR code. During the pandemic many government support schemes were delivered using Pao Tang, an open mobile digital wallet application developed by the SOE KrungThai bank, which utilizes the Promptpay infrastructure. The scope of Pao Thang has expanded as public and private sector utilize the platform to offer services ranging from investment products (low-value government bonds and gold) as well as healthcare (e.g., check entitlement for medical services and make appointment to avail themselves of these services) and lotteries.

Togo has a digital payment system and is beginning to develop its digital ID. The e-payment system is based on mobile money, with the dominant service being T-money, developed by the SOE, Togocel. During the pandemic, the Novissi program delivered emergency transfers to 819 thousand informal workers through mobile money. Workers also registered for the program with their feature phones. Beneficiaries were identified through their voter registration IDs, and listed occupation on these IDs. Machine learning and AI was applied to mobile phone data to identify the poorest informal workers in the poorest parts of the country. Togo is working with development partners to introduce a digital ID using the open-source software MOSIP, developed by a university in Bengaluru.

Chile is beginning its digital transformation at societal level with the establishment of a digital ID. Clave Única is a centralized service that allows people to validate their identity on the web platforms of public agencies to access to the government data and procedures available, always using their identification number and a password defined by the same person. Until January 2023 Clave Única has registered 14,573,731 users, which represents 88.5 percent of the people who can obtain it. Users with a Clave Única can access 1,730 government services and procedures, which corresponds to 85% of all central government procedures that require some authentication mechanism to carry them out.

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