



# Digital Technology for Inclusion: The India Story

# Digital Technology for Inclusion: The India Story

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## EXECUTIVE SUMMARY

Using India as a case, this briefing looks at how the use of digital technology by the government and private sector is helping to change society, largely for the better. It explores how digital technology has enabled more people to access benefits and expand their economic opportunities in new ways that were elusive even a decade ago. Cheap broadband, cheap storage space, the cloud, and widespread availability of smartphones present new opportunities for greater *inclusiveness* of growth. In India, because of deregulation and hyper-competition among telecom operators, data is almost free. The adoption of 5G cellular (trials of which will be conducted in late 2019), with its greatly enhanced network speed and capability for data transmission, has the potential to amplify these benefits.

The research highlights areas where India's digital strategy has enabled government and private sector solutions to reach poorer people who were previously largely shut out from the benefits of globalization. The foundational technology that acts as a key driver of this change is Aadhaar, India's biometric-based digital identification system, which has received almost universal adoption by India's 1.3 billion citizens, and India Stack, a complementary set of enabling technologies. Through Aadhaar, India has enabled its population to verify their identity in order to access basic services including receiving government benefits, opening bank accounts, and applying for loans. India's relatively open markets and India Stack's open application programming interface (API) allow private companies to write software for the system and leverage its capabilities.

Digital technology has enabled broader populations to participate in the economy in other sectors as well. In agriculture, which employs about half of India's population, farmers are able to use precision agriculture applications to better manage their harvests and prepare for extreme weather.<sup>1</sup> Digital marketplaces help them exercise more control over how they market and sell their crops.

In education, technology-enabled platforms are helping to deliver a wide variety of curricula to broader populations and lessons tailored to varied student needs. And new methods help students and current workers prepare for the future technology-driven economy. In healthcare, technology could narrow the urban-rural divide in quality and availability of care, ensuring more accurate and efficient diagnoses. In some cases, as this briefing shows, hybrid models emerge that combine high- and low-tech approaches, as with delivery of medical care in rural areas.

The examples from India are specific to the country but can provide lessons for other countries considering adopting national digital identification systems and other digital technologies to foster inclusion of broader segments of their populations. This briefing seeks to illustrate how, by putting in place forward-thinking technology infrastructure and harnessing the power of digital technology, India has set the stage for continued improvement in economic and social well-being and opened new markets for various sectors at the same time (see Figure 1 for company examples).



## INTRODUCTION

India is the world's fifth-largest economy, and among the fastest-growing.<sup>2</sup> But its per capita income, at around \$2,016 annually, ranks a low 139<sup>th</sup>.<sup>3</sup> Although India's economy benefited from structural reforms in the early 1990s and is relatively open to outside investment, many of the benefits accrued to the rich. The top 1% of India's population own over half of the country's wealth while the bottom 60% own less than 5%.<sup>4</sup> Despite its steps forward, India still has the world's second-largest unbanked population, at 190 million people. As is the case globally, a disproportionate share of these are women.<sup>5</sup>

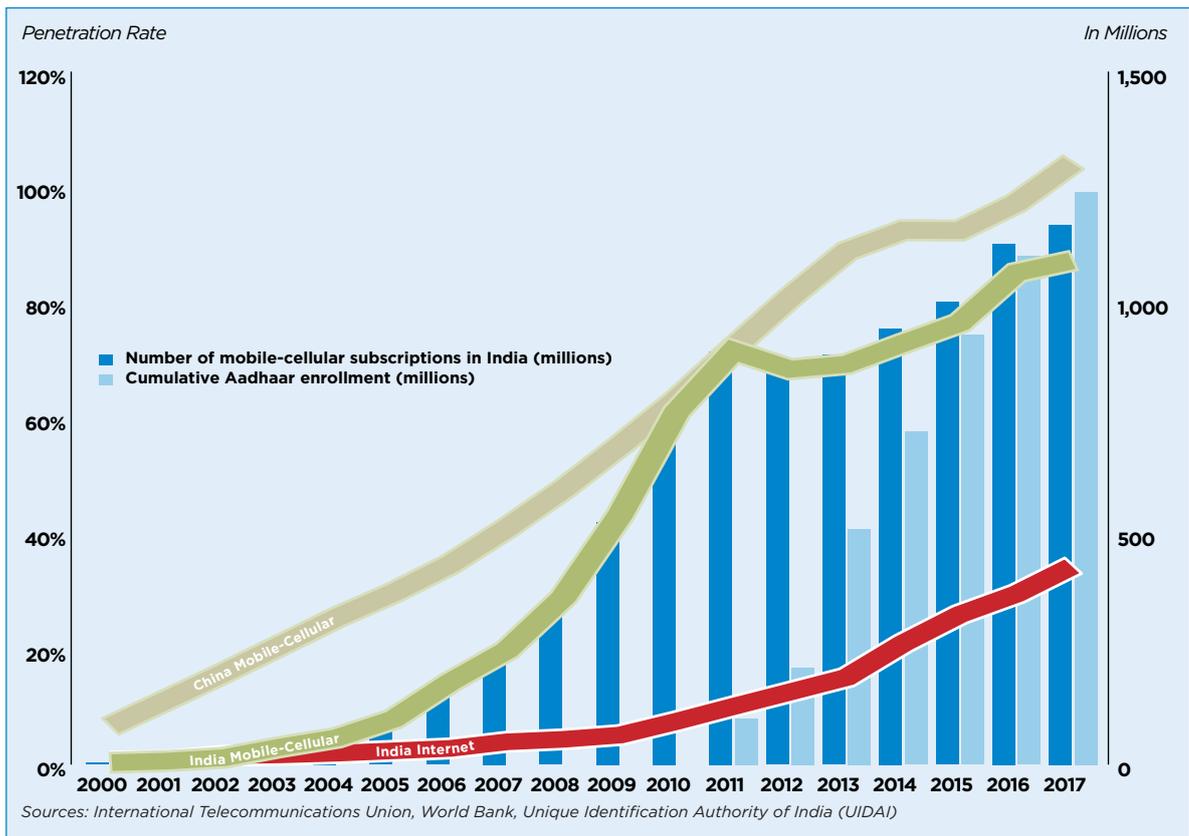
Farming employs roughly half of India's people, although its share of GDP in 2018 was only about 15%.<sup>6</sup> In 2016, Prime Minister Narendra Modi promised to double farmers' incomes by 2022, in an effort to appease farmers who have increasingly borne the brunt of crop failure due to drought and erratic monsoons. A series of inefficient and convoluted agricultural subsidies hamper the delivery of support to rural farming families.

The country faces great education challenges, with access to education and poor education outcomes being foremost. With a population of 1.3 billion, India will be the world's youngest country in 2020. Results from the last Indian census in 2011 found that while the overall literacy rate is rising, the literacy rate is 67% in urban areas but only 53% in rural areas.<sup>7</sup> The education system also falls short in preparing its young people to transition from school to work. Compounding these issues, India's rate of job creation is well behind that needed to employ the more than 12 million youth between the ages of 15 and 29 expected to enter India's labor force every year for the next two decades.<sup>8</sup>

Opportunities for using digital technology to tackle divides along economic, social, and educational lines are immense. Indians are avid users of digital technology. The country's telecommunication network is second only to China's by number of mobile phone and internet users. Even in rural India, where the vast majority live on an income of Rs. 33 (\$0.46) per day, roughly three-quarters of the population owns a mobile phone.<sup>9</sup>

A number of homegrown Indian technology platforms play key roles in creating the foundation for the digital economy to flourish, providing widespread, affordable smartphone and internet adoption. Reliance Jio, led by Reliance Industries' Mukesh Ambani, is one of the world's largest mobile network operators, serving about 340 million subscribers in India. Reliance Jio has leapfrogged landline telephony. Its network's geographic coverage has the potential to reach 99% of India's population, and at the lowest cost per gigabyte globally.<sup>10</sup> Almost 90% of the Indian population uses mobile-cellular services (see Figure 2). Reliance Jio's strategy of bundling virtually free smartphones with mobile service subscriptions has spurred innovation and competitive pricing. Data costs have plummeted by more than 95% since 2013 and fixed-line download speeds have quadrupled between 2014 and 2017.<sup>11</sup> India's National Digital Communications Policy, adopted in 2018, aims to provide universal broadband connectivity for all geographic areas by 2022.<sup>12</sup>

The Aadhaar system, the world's largest biometric identification system, assigns 12-digit unique identity numbers to residents in India. These numbers can be used to obtain government benefits and subsidies, access public facilities, and register for various government services. Over 1.24 billion out of India's 1.3 billion citizens have signed on.<sup>13</sup> (China's WeChat-linked electronic social security card system could eventually become a larger national digital identification system, as WeChat already has more than 1 billion monthly active users, though this system is still being piloted in selected cities). Combined with fast data speeds from the internet backbone, Aadhaar, together with India Stack, which enables access to a variety of services on-demand, has laid a foundation to enable financial inclusion as well as commerce and innovation.<sup>14</sup>



**FIGURE 2**  
GROWTH IN MOBILE-CELLULAR, INTERNET, AND AADHAAR SUBSCRIBERS IN INDIA

## AADHAAR: A FOUNDATIONAL DIGITAL TECHNOLOGY FOR INDIA

Aadhaar, which means “foundation” in Hindi, is a digital proof of identity which is provided free and is available to every Indian. The Aadhaar identity platform is one of the key pillars of the Indian government’s Digital India initiative.<sup>15</sup> Together with a complementary set of enabling technologies, known as India Stack, Aadhaar has fostered financial inclusion by increasing access to bank accounts and financial products to groups in need, like farmers. At the same time, it has spurred private sector innovation and given a boost to the digital financial services industry.

Aadhaar is run by the Indian government’s Unique Identification Authority of India (UIDAI). It was developed by Nandan Nilekani, along with a group of private and public sector collaborators. The system design began in 2009. The first official enrollment took place in 2010, when Ranjana Sonawane received her Aadhaar card at her village, Tembali, in Maharashtra with Congress President Sonia Gandhi and then-Prime Minister Manmohan Singh looking on.

Citizens register for Aadhaar at local Aadhaar centers by giving their name, gender, address, and date of birth and allowing the system to record a scan of their irises and fingerprints. Each registrant’s Aadhaar number, a unique 12-digit number, known as the Unique ID (UID), is generated, following biometric de-duplication (a process that checks to make sure the user demographics and biometrics are unique).<sup>16</sup> Once the number generation process is completed, registrants can log into the UIDAI website to receive their Aadhaar numbers. They will get their official Aadhaar cards in the mail. Each card bears a photo of the registrant, along with his or her name, date of birth, gender, address, and Aadhaar number. The cards have no smart card features, and they can be downloaded from the UIDAI website if lost.<sup>17</sup>

To receive authentication for a transaction or an Aadhaar-linked service, individuals can use a combination of their demographic and biometric information, or demographic information plus a one-time

payment (OTP) code or a quick response (QR) code from the UIDAI website. These two options are received by the user through a mobile phone or computer print-out and contain an encrypted version of his or her information that cannot be re-used or stored by others.<sup>18</sup> Biometric information is given through various means, such as fingertip or iris scans, by a point-of-service device like a micro ATM, a USB device connected to a PC, or a mobile phone with a biometric sensor.<sup>19</sup>

For remote villages or places where people are illiterate or do not have phones, the government rolled out micro ATM devices which authenticate users through their fingertips.<sup>20</sup> There were around 400,000 micro-ATMs in use in 2018, according to the UIDAI.<sup>21</sup> Axis Bank was the first to market a UIDAI compliant micro-ATM tablet with built-in iris scan technology.<sup>22</sup> Aadhaar e-payments flow using India's Universal Payments Interface (UPI), which is part of India Stack (discussed below).

Aadhaar helped solve a severe problem for India in that it has allowed much more efficient delivery of the roughly \$46 billion per year of subsidies—welfare, pensions, and other types of government programs—paid from the government to the Indian people.<sup>23</sup> Overall, India's subsidy system suffered leakage of a staggering trillion rupees (\$13.8 billion), nearly a third of the government's expenditures on welfare schemes due to fraud, errors, and inefficiencies.<sup>24</sup> Since many Indian citizens lacked foundational identification documents, identity scams were rampant. The system is now much more transparent, and much fraud has been eliminated.

Aadhaar has enjoyed almost universal acceptance, reflecting its usefulness. Enrollment is nominally voluntary, yet it is mandatory for filing of income tax returns and must be linked to one's Permanent Account Number to prevent tax evasion. The Permanent Account Number is a number used to track financial transactions that might have a taxable component.<sup>25</sup> At a cost of about \$1 per person to build, design, and rollout, Aadhaar has paid for itself many times over. Savings to India are estimated to be about \$13 billion as of 2018.<sup>26</sup> The Indian government has sent payments of over \$57 billion through 3.2 billion direct transfers using Aadhaar since inception.<sup>27</sup>

The Aadhaar project has made life easier for millions. Those who were unbanked, and even many of those who had bank accounts or lived in villages that lacked a bank branch, lost time and money traveling and waiting in long lines for disbursements. Aadhaar and other programs have brought more people into the formal financial system and made it easier for them to transact. Thanks to the government-sponsored program, Jan Dhan Yojana (People's Wealth Scheme), which is credited with increasing financial inclusion by 27% between 2014 and 2016, over 300 million new bank accounts were opened.<sup>28</sup> Many more bank accounts (870 million as of 2018) are now linked to Aadhaar.<sup>29</sup> Recipients can now receive their payment into their bank accounts and transact through the UPI network using their mobile phone or by touching their fingertips to micro ATMs, which are point-of-sale devices operated by retail agents authorized by banks to extend the network. These authorized agents are often small merchants in villages.

One use case in which Aadhaar has been particularly helpful is delivering subsidies to smallholder farmers, according to a study by the World Bank's Identification for Development (ID4D) project, whose mission is to help countries realize the transformation potential of inclusive, robust, and responsible digital identification systems.<sup>30</sup> Under Section 7 of the Aadhaar Act, which was upheld in a 2018 decision by the Indian Supreme Court, a farmer's Aadhaar must be linked to the system in order to receive fertilizer subsidies, and for the large-scale Public Distribution System, which provides subsidized food to the majority of rural India.<sup>31</sup> In both cases, ID4D found that Aadhaar improved efficiency by reducing fraud and so-called ghost recipients, fictional beneficiaries who are ineligible, or, in some cases deceased. The ID4D also found it helped female farmers obtain benefits by demonstrating individual ownership of assets and acted as a bridge to financial services by enabling farmers to open government-sponsored Jan Dhan bank accounts. Farmers not only benefitted from being paid subsidies directly to their accounts, but also from having a record of their financial transactions in those accounts, which enabled them to apply for credit more easily.<sup>32</sup>



## IDENTITY AND TECHNOLOGY: NANDAN NILEKANI SPEAKS

Infosys co-founder and non-Executive Chairman Nandan Nilekani in 2009 retired from the company to chair the launch of India's Aadhaar digital identity system, allowing direct government subsidy payments and easier opening of banking and mobile phone accounts. Nilekani also helped develop India's electronic payments system and the initial architecture for the Goods and Services Tax (GST), which now collects about \$15 billion a month. The following are excerpts from an interview on digital identity and technological opportunities.

### WHAT HAS AADHAAR ACCOMPLISHED IN THE 10 YEARS SINCE IT STARTED?

Today over 1.2 billion people have a digital identity. This has enabled online authentication and e-KYC [Know Your Customer]. India's payments system, UPI, now does 800 million transactions per month worth \$25 billion.

### WHAT'S NEXT?

One next stage is health care. The government has rolled out insurance for 100 million families nationwide. The next part is electronic health records and so on. In education, my wife and I set up EkStep; it is being used across India in 27 states. That will be the next big area. Next is the judicial system. India has a slow and cumbersome judicial system, with cases held up for years. It will really help the economy to be able to settle disputes faster.

### WHAT METRICS DO YOU USE WHEN YOU LOOK AT EDUCATION?

We are focusing on how to get digitally enabled textbooks. We have developed digitized textbooks, putting QR codes in the textbook. The topic pops up on your phone. For science, in a section on the solar system, a quiz on it pops up. Every year the state governments reprint textbooks. In the last two years, 27 states have reprinted using QR codes. There are now 400 million textbooks with those codes.

### DOES THIS WORK WITH EXISTING TECHNOLOGY?

Users need a smartphone. Smartphones are available for \$100 to \$150. India now has 350 million smartphones and they are in the hands of parents or teachers, not kids. The content can be seen on your phone, on a PC, even a projector. The system is very flexible.

### HOW DOES INDIA COMPARE WITH CHINA?

We built the ID system and wanted to be sure it was privacy protecting. Aadhaar only does the ID. If an ID is used in healthcare, the healthcare records stay in the healthcare system. It's not a data collecting system. On the payment side, in China, two companies dominate: Alipay and WeChat. India's banking regulator RBI has set up NPCI [National Payments Corporation of India]. It's a non-profit, bank-owned company, and the payment rail it provides is very cheap and highly scalable. India thus has an interoperable mobile payment system with competing payment apps — Google Pay, WhatsApp, Amazon Pay, Paytm, PhonePe, etc.

### HOW HAVE AADHAAR AND RELIANCE'S HIGH-SPEED JIO NETWORK INTERACTED?

By the time Jio was launched close to one billion people had Aadhaar. Jio has made an astonishing difference to India's net-

works. They made data freely available for the cheapest price in the world. Jio also benefited from Aadhaar. Because of online authentication from Aadhaar, the e-KYC, Reliance Jio could open a mobile connection in two minutes. They offered free connections for six months, signing up one million mobile customers a day. They built up a base of 100 million customers in six months.

### WHERE DOES THE LEGAL BATTLE OVER PRIVACY STAND?

Aadhaar had a nine-year history in the Supreme Court. People asked about whether Indians had a fundamental right to privacy. A nine-judge bench said they do have a right to privacy but the government can circumscribe it. Aadhaar was tested and upheld as upholding privacy, but in that judgement, the Supreme Court said the private sector could not use it. So now the new government has passed a law that for banks and telecom companies voluntary use is allowed.

### HOW DOES AADHAAR CONTRIBUTE TO FINANCIAL INCLUSION?

Aadhaar has given people an identity — banks can do an e-KYC and open bank accounts quickly. There are 300 million new bank accounts. That is one part. The second is bank accounts have been linked to IDs and electronic benefits and money transferred to bank accounts. That is a form of financial inclusion. That has created inclusion through the world's largest cash transfer program. The third way is the UPI payments system, allowing cashless digital transactions. People are creating digital footprints and can apply for loans.

### DOES IT HELP ON SOCIAL MOBILITY?

It absolutely helps on social mobility. A lot of people didn't have identity before it came along. The number is simple information. There's no information about ethnicity, caste, income, nothing. It increases physical mobility and help get better access to healthcare or education of financial services.

### DOES AADHAAR HAVE LESSONS FOR OTHER COUNTRIES?

There is tremendous interest worldwide. Legal identity for all is one of the sustainable development goals for 2030. We now have a group at the World Bank called ID4D — Identification for Development. About 20 countries are looking at some kind of digital identity. Identity has become a global development topic and many are looking at the India experience.

The World Bank's ID4D project notes that although Aadhaar was introduced before a legal and regulatory framework was enacted, it builds in privacy by design, by not collecting user information in an ongoing way.<sup>33</sup> Aadhaar authentication queries from third-party users to the central UIDAI database (whether using the online or offline method) receive a simple "yes/no" response, indicating whether or not the person's identity factors match records maintained by UIDAI, the agency responsible for Aadhaar.<sup>34</sup> Created as a "dumb" ID in technology parlance, meaning it does not collect data on the individual, Aadhaar skirts some thorny issues currently cropping up around data ownership. According to the UIDAI website, the "Aadhaar number is devoid of any intelligence and does not profile people on the basis of caste, religion, income, health, and geography." It is not, by design, capable of being used by the state or businesses to create a social score or track individuals' purchasing behavior.<sup>35</sup>

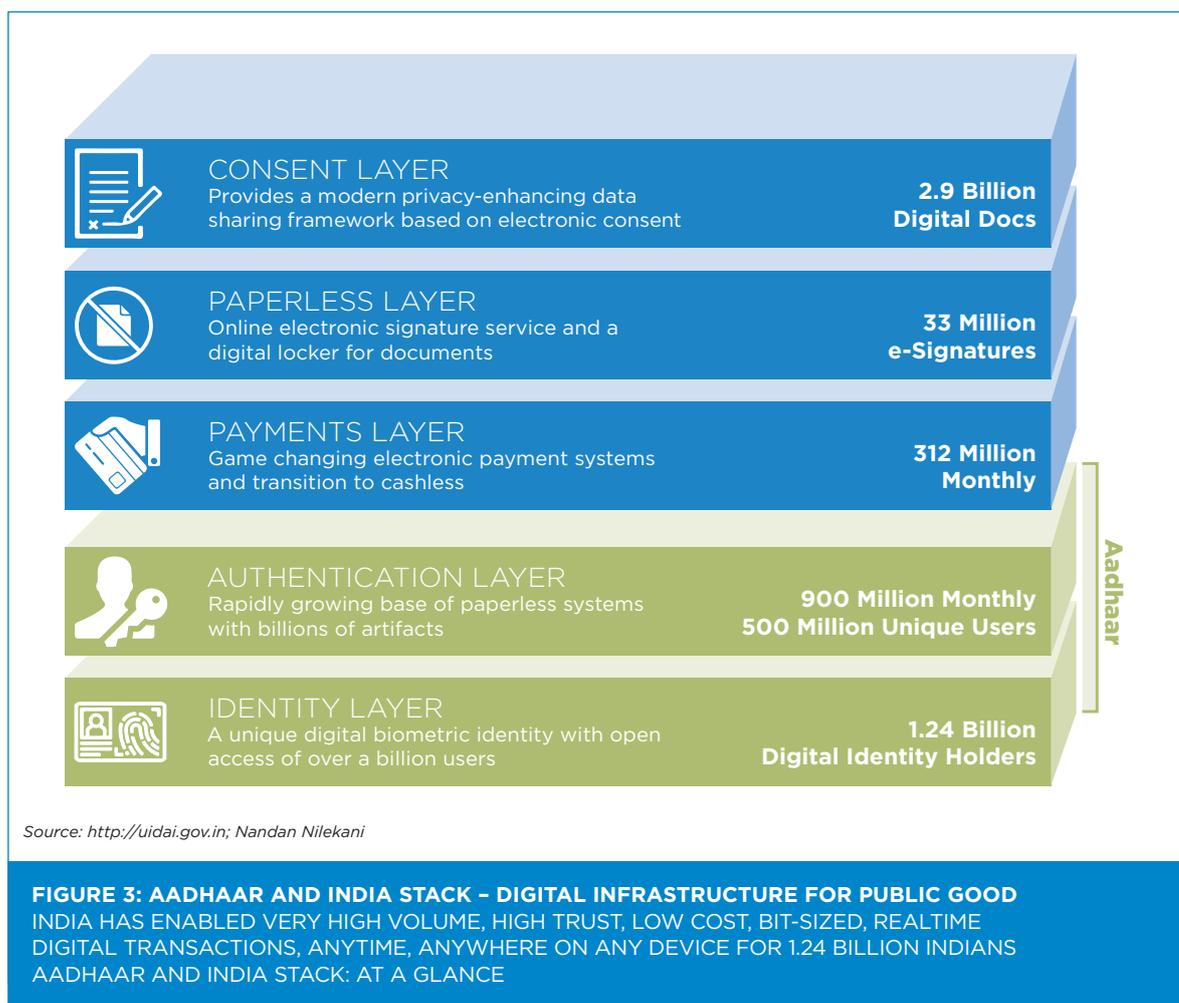
The Aadhaar unique national identification system has garnered interest from other countries looking to employ digital identity for their populations, as a means to advance development.<sup>36</sup> In 2018, the International Institute of Information Technology in Bengaluru, India helped Morocco build an open source Aadhaar-like digital identity platform called the Modular Open Source Identity Platform (MOSIP). The United Kingdom has announced the establishment of a dedicated cross-departmental Digital Identity Unit in June 2019. Philippine President Rodrigo Duterte has shown interest in adopting an Aadhaar-like system.

## FINTECH AND INDIA STACK

India Stack is the name for several additional design layers that interact with Aadhaar (see Figure 3). India Stack's open API design means private sector companies can use its capabilities, including an Electronic Know Your Customer (e-KYC) function launched in 2012, and digital signature capabilities.<sup>37</sup> "Know your customer" rules are in place in industries like banking and financial services, as well as telecoms, to reduce fraud, money-laundering, tax evasion, and financing for terrorism. When opening new customer accounts, identity verification by e-KYC is much faster than traditional methods, which require numerous physical documents.

There are two ways to do an e-KYC authentication using Aadhaar: online and offline. So-called offline is done without biometrics. Any Aadhaar number holder who desires to establish his or her identity to a service provider enabled for Aadhaar paperless offline e-KYC requests a secure, digitally signed, sharable document in QR code or digital form from the UIDAI website, by computer, SMS or by using the mAadhaar phone app, which then can be used to complete a transaction. The Aadhaar number of the person is not revealed; instead, only a reference ID is shared.<sup>38</sup> Online authentication requires fingertip or iris scanning with a biometric device (like a micro ATM or other point-of-sale device) by the service provider, in addition to an Aadhaar card, Aadhaar number, or some combination of data collected at the time the number was generated.

India Stack's "payments layer," known as the Unified Payments Interface (UPI), was launched in 2016 by the National Payments Corporation of India (NPCI), India's umbrella organization for payments that was created by the Reserve Bank of India (RBI) and the Indian Banks Association.<sup>39</sup> UPI was built on the backbone of India's Immediate Payment Service, launched in 2010, which is one of the most evolved and sophisticated digital payments infrastructures in the world.<sup>40</sup> UPI's payment rails are ranked among the best in the world.<sup>41</sup> India's system now allows real-time e-payments between banks, e-wallets, individuals, merchants, and mobile phones, and is the means by which many government subsidy payments are sent to recipients. The UPI overlay, with its open API, meant that software developers could write code for it, thus spurring the growth of a vibrant financial-technology (fintech) industry, including UPI-enabled e-payments and mobile wallets, as well as banking, insurance, and other services. Prior to these innovations, retail money transfer often took days and was costly to the



user. Transaction data reported by RBI show that payments over UPI total Rs. 1.55 trillion (\$22 billion) monthly, as of August 2019.<sup>42</sup>

The e-payments sector enjoyed a boost from demonetization, the term for the abrupt decision by the Modi government in November 2016, shortly after UPI started, to remove 86% of the country's bank notes from circulation. The process was a boon to both UPI's payment interface, called Bharat Interface for Money (BHIM), which enables payments through a QR code system called BharatQR, as well as private sector e-payments companies. Paytm, a UPI-integrated digital wallet e-payments firm, which at the time was India's largest, took out an ad congratulating Mr. Modi for the move.<sup>43</sup> Because India has much lower levels of credit card usage than in western countries, QR codes are a simple and viable way to initiate transactions and reduce the high use of cash. QR codes are enjoying increased acceptance even by India's micro-merchants.<sup>44</sup>

UPI is well-integrated with the banking system and Aadhaar-enabled benefits. BharatQR is supported by all major banks and interfaces with all mobile wallets. Banks benefit from getting fine-grained information on customer transactions that can be used for credit analysis and customization. By contrast, in China's market, which is essentially closed to foreign entry, the two dominant payment apps, WeChat Pay and Alipay, together account for 92% of the market.<sup>45</sup> They send transfers between their digital wallets, to which banks are blind. The Chinese government recently mandated that these transactions route through an official clearinghouse in an effort to make the data visible to the state.<sup>46</sup>

India's newly minted fintech companies have leveraged the India Stack platform to reinvent the cost structure in the space, which allows them to reach a different set of borrowers than banks previously

could underwrite. For a person wishing to build up a credit history, using e-payments services like digital wallets can help. An individual's record of digital payments and other transactions gives financial services companies a credit history that those companies can use to gauge the individual's ability to repay a loan. Thus, many people who just 10 years ago would have been invisible to providers of credit due to lack of a formal credit history have become an attractive new market.

With the advent of AI, automated risk-based credit scoring using mobile phone data to underwrite an individual or small business owner is more cost-effective than laborious branch-based underwriting by human beings. That makes smaller loan sizes more profitable. A natural pairing is for banks to partner with fintech companies, offering a balance sheet and a risk-sharing deal in exchange for the nimbler underwriting skill of the fintech company.<sup>47</sup> Banks are bullish about this opportunity to offer products to a larger customer base enabled by fintech partnerships.

Indian fintech companies, including Capital Float and LendingKart, are examples of this trend toward automation and smaller loan size helping to reach underserved small and medium enterprises (SMEs). Capital Float is an online platform that provides working capital finance. It offers flexible, short-term loans for SMEs to improve cash flow and grow their business. LendingKart is a non-deposit taking non-banking finance company, which relies on the markets and partners with banks for funding. It uses technology and analytics tools to model and analyze thousands of data points from various data sources to rapidly assess the credit-worthiness of small businesses. To be sure, these businesses are not immune to the credit cycle. But they are examples of how fintech extends financial inclusion, by allowing an individual small business owner's data trail to become "visible" to the formal financial system.

## AGTECH

Agriculture in India faces pressing challenges including water shortages, erratic monsoons, and low agricultural productivity in the face of rising food demand. How India copes with this will have momentous human consequences, as India is projected to overtake China as the world's most populous country by 2027.<sup>48</sup>

India is the world's biggest grower of cotton and the second-largest producer of rice, wheat, and sugar.<sup>49</sup> Agriculture employs almost half of India's population. It accounts for around 90% of India's annual water consumption, but due to the low rate of productivity, makes up only about 15% of the country's GDP.<sup>50</sup> India has a severe water problem. It is home to nearly one-sixth of the world's population but has only 4% of the Earth's fresh water.<sup>51</sup> More than half of the country faces high water scarcity. Twenty-one major Indian cities are projected to run out of groundwater by 2020, including New Delhi and Bengaluru, according to a study by government think tank NITI Aayog.<sup>52</sup>

A glib saying has it that "the monsoon is India's finance minister," given the importance of the summer monsoon for the country's farmers and thus the health of its overall economy. To reduce dependence on rainfall, the government has approved Rs. 500 billion (\$6.7 billion) in spending on various irrigation projects in the five years ending March 2020, the latest in a series of large-scale irrigation projects that date back to the nineteenth century. But almost half of the country's farmland still depends on rainfall for water.<sup>53</sup> Through irrigation canals first developed in the British colonial era and tube wells that drain groundwater, arid areas in the northwest, rather than water-rich states in the east, became India's breadbasket.<sup>54</sup> These areas such as Punjab have increased output, but their long-term environmental sustainability is in question because of changing weather patterns and aquifer depletion.

More than 70% of India's annual rainfall comes during the June to September monsoon.<sup>55</sup> Increasingly erratic monsoons have caused more frequent floods and drought. Resultant crop failure has contributed to mounting farm debt. This has put intense pressure on the livelihoods of farmers. The inability of many farmers to repay their loans, combined with other factors, has resulted in a tragic number of suicides. Official data show some 321,000 cases of farmer suicides nationwide between 1995 and 2015,

after which the government stopped publishing these numbers.<sup>56</sup> State-level data show that in Maharashtra, more than 12,000 farmers committed suicide between 2015 and 2018.<sup>57</sup> The state was hit hard by drought in 2018, and 808 farmers ended their lives in the first four months of 2019, which translates to almost seven suicides every day.<sup>58</sup>

The use of technology to tackle farming problems in India is not new. When the Green Revolution started in India in the 1960s, farmers boosted harvests with high-yielding varieties of rice and wheat, increased fertilizer, pesticides, and new methods of irrigation. Cereal yields jumped almost 90% from 1970 to 1995.<sup>59</sup> However, such farming methods were unsustainable. Decades of heavy subsidies on fertilizer, energy, and water led to over-consumption.<sup>60</sup> Excessive use of chemicals and pesticides, exacerbated by the perverse effects of government subsidies, led to a loss of soil biodiversity and increased pest resistance.

In Maharashtra, the government is using drones to improve water management. In what is one of the largest agricultural land surveys to date, the Water Resources Department of the Maharashtra Krishna Valley Development Corp., together with Japan-based partner company Terra Drone, completed an aerial survey of 4,200 square kilometers of agricultural land. Using drones helped update archaic maps that had not been refreshed in decades, and it gave the Water Resources Department a clear picture of the crops sown in the area and the type of irrigation being used. This will contribute to more efficient water use in future.<sup>61</sup>

Drones are also being used for precision farming in Maharashtra to enable farmers to spot the difference between healthy and distressed plants too subtle to be detected by the human eye. Drone technology allows farmers to take early action to prevent the spread of crop disease. The use of drones is not yet commonplace on India's farms. Aside from a dearth of trained pilots, drone technology is unaffordable for most of India's small holder farmers. India Flying Labs (IFL) is a knowledge-sharing network for applying technologies for social good, which is part of the U.S.-based non-governmental WeRobotics. IFL is making drone technology accessible to local farming communities. IFL trainers are teaching villagers in Maharashtra how to use drones equipped with cameras and sensors to gain better insight into soil conditions and plant health.<sup>62</sup> IFL helps farmers obtain financing for drones. Farmers can apply individually or collectively for grants and loans from IFL, which also trains farmers to analyze the data they collect.<sup>63</sup>

In another attempt to expand the benefits of precision farming to more farmers, engineering students from Lovely Professional University in Punjab have designed low-cost drones. Their drone, called "Flying Farmer," costs Rs. 10,000 to Rs. 15,000 (\$139-\$209), which is a fraction of the price of traditional drones.<sup>64</sup> Equipped with computer vision and infrared sensors, Flying Farmer drones cut down on the overuse of pesticides by detecting the position of weeds and spraying pesticides with more precision than if done manually, which helps prevent waste or overuse. Results of field trials showed a 15-20% improvement in crop yields.<sup>65</sup>

Precision agriculture improves crop visibility by enabling farmers to detect problems early, respond to threats, and minimize waste.<sup>66</sup> Drones, sensors, and satellite imaging help to collect data on weather patterns, soil nutrient, plant health, and terrain features. This helps predict what crops to plant in order to optimize the use of pesticides and fertilizers. More accurate forecasts for crop patterns and yields have also enabled companies like SatSure to build a credit-rating system for small farmers. By giving more assurance to lenders and insurers about harvest potential, farmers should be able to access cheaper credit and insurance protection, a change that could increase incomes and even prevent suicides. While the benefits of precision farming will likely first accrue to larger farms, the emergence of digital platforms for farm equipment rental and trading produce has also opened up new opportunities for small farmers.

Digital marketplaces have sprung up, allowing farmers to connect to new markets, rent equipment, and pool risk for better insurance rates. Prime Minister Narendra Modi in 2016 launched the National Agriculture Market (eNam) in an attempt to build a unified market for agricultural products and eliminate middlemen. But eNam received a tepid response, with only 14% of farmers showing interest, due to legislative

and technological bottlenecks.<sup>67</sup> Not all states approved the needed electronic auctions. And farmers felt the eNAM platform's lack of scientific grading facilities would result in lower prices for their product.<sup>68</sup>

Some private companies also have made efforts to improve market access for small farmers. Founded in 2015, Ninjacart, a Bengaluru-based business-to-business (B2B) fresh produce supply chain company operates a market platform that has met farmers' needs more successfully. Through it, some 13,500 vegetable and fruit farmers from villages across 20 states ship produce daily to retailers in seven major cities.<sup>69</sup> Ninjacart has added value to India's agricultural supply chain by eliminating inefficient middlemen and increasing demand transparency for small farmers. It uses machine learning to estimate demand and price for produce prior to harvest in order to reduce waste. According to its website, farmers receive 20% more on average for what they produce and are paid within 24 hours.<sup>70</sup> Farmers also save time transporting produce to cities by using collection centers that are set up within a 20-kilometer radius from their farms.<sup>71</sup> The startup received a commitment for a \$50 million investment from Walmart in August 2019, after closing a \$100 million Series C funding, boosting total funds raised to \$200 million.<sup>72</sup> Investors also include Nandan Nilekani and Syngenta.

Renting farm equipment has also become a trend among Indian farmers that may help increase productivity. The OECD estimates that 85% of operational land holdings in India are less than two hectares, or the size of two soccer pitches.<sup>73</sup> Indian farmers use little machinery, with a study showing that just about 5% owned a tractor and just 0.2% had a mechanical harvester.<sup>74</sup> Part of the reason is the small plot size that makes the use of large machinery difficult and uneconomical. Companies like Mahindra & Mahindra's Tringo have built online platforms to rent tractors to farmers. Rival EM3, which first started its operation in Uttar Pradesh, has extended its footprint to Rajasthan and Madhya Pradesh through partnerships with local governments.<sup>75</sup> Hello Tractor is the latest to jump on the bandwagon. Dubbed the "Uber for tractors," U.S.-based Hello Tractor has developed a special tractor for farmers with small plots – a two-wheel, GPS-powered smart tractor that can easily maneuver around small areas, which allows small farmers to rent tractors through SMS on a just-in-time basis, a model it pioneered in Africa. Hello Tractor announced the launch of its service in India in September 2018 through a partnership with cellular network provider Aeris. The collaboration, although started as a pilot program in states such as Uttar Pradesh and Bihar with 500 tractors, plans to cover other farm machines, such as harvesters and combines.<sup>76</sup>

## EDTECH

India is the country with the greatest potential demographic dividend in Asia. About 50% of its population is below the age of 25, and more than 65% is under 35. It will have the world's largest working-age population by 2027, with more than 1 billion people between the ages of 15 and 64.<sup>77</sup>

Digital technology has created new opportunities to tackle India's greatest education challenges. It helps to broaden access to education and improve education outcomes for those at the bottom of the pyramid through digital technology platforms, mostly using existing devices rather than investing heavily in upgraded equipment. Also, digital technology is being used to improve the skills of current workers in digital literacy so they can participate in gainful employment in the digital economy.

In India, over 60% of children aged 6 to 14 years cannot read at the second-grade level, although the country's primary school enrollment rates reach over 95% amid continued increases in education spending.<sup>78</sup> According to the World Bank's Human Capital Index in 2018, the expected years of school that Indian students receive is 10.2 years, but the years of school adjusted for standardized test scores is just 5.8 years, showing that learning outcomes are dismal.<sup>79</sup>

In the past two decades, a number of technological initiatives have been used to help bridge the digital divide. Technology access has increased, due in part to the provision of cheap laptops by well-mean-

ing organizations over the years. The One Laptop Per Child (OLPC) program, founded by MIT professor Nicholas Negroponte in 2005, provided \$100 laptops meant to increase technological access to children in developing countries. However, the laptops had low adoption rates in many developing countries, including India, due to the lack of infrastructure and technical support. Low-cost devices also suffer from lower quality and do not work in the absence of a sustainable ecosystem supporting their usage, particularly connectivity, basic education, and digital literacy. The Aakash low-cost laptop program, launched in 2011 and aimed primarily at university students, was hampered by the lack of connectivity and technical support.

These challenges stand in contrast to the top end of technology-enabled education in India, which has been growing very rapidly. The services of private tutoring, test preparation, and online learning platforms have benefited many students living in urban areas and expanded levels of achievement. India's edtech market is valued to be around \$2 billion by 2021.<sup>80</sup> From 2014 through 2018, 182 Indian edtech startups were funded with a total of \$1.34 billion. Of this, about 77% was poured into just four edtech companies – BYJU'S, Toppr, Unacademy, and Vedantu – with a \$500 million funding round for BYJU'S in 2018.<sup>81</sup>

Poor education outcomes in remote, non-urban areas can often be attributed to basic issues ranging from poorly qualified or absent teachers, to functionally illiterate parents, to the lack of quality textbooks. New technology helps to fill this gap.<sup>82</sup> One edtech unicorn company, BYJU'S, has sought to bring its learning platforms to more students living in more remote areas. The Indian-based edtech unicorn tackles what it sees as key challenges that traditional education faces, including the lack of quality teachers, overcrowded classrooms with large teacher-student ratios, and students' fear of exams and lack of passion for learning as a result of exam-focused curricula. To target these issues, the co-founders designed its education platform to engage students and help them learn more effectively. Since 2015, BYJU'S has 35 million student users, 75% of whom reside outside India's top 10 cities.<sup>83</sup> This is about one-tenth of all of India's youth. The platform focuses on teaching fundamentals in math and science and fostering a love for learning.

New foundations like EkStep in India have also stepped in, in an effort to vastly improve access to learning opportunities. Founded by Infosys's Nandan Nilekani and Rohini Nilekani and Marketics' Shankar Maruwada, EkStep is an open edtech platform with a collection of learning resources in literacy and numeracy. Its goal is to provide the public good of education at scale, through granting access to various curricula that can improve students' basic skills including reading, writing, and math. This digital infrastructure is open to policy makers, curriculum designers, teachers, parents, tutors and others to contribute and access content, using their existing tablets and smartphones.<sup>84</sup> Using QR codes, the content of 400 million textbooks can be uploaded to phones and then projected in classrooms for teaching, vastly expanding the availability of teaching materials in remote areas and the range of topics that can be taught even in more poorly resourced schools.<sup>85</sup>

Beyond basic education, continuous skills retraining and improvement has also emerged as a major concern, given that India has to improve the skills of current workers to adapt to the digital economy. Increasingly, human workers will need to work with machines and algorithms in a digitally driven economy. This is a problem even for educated workers. A study by the Associated Chambers of Commerce and Industry of India found that only 7% of India's business school graduates were employable, due to inconsistent quality of education, apart from the top business schools, relative to the evolving needs of the corporate sector.<sup>86</sup>

Skills training for workers in India remain severely inadequate, representing untapped human potential. Businesses can help by using technology to increase access to match education and skills with decent jobs for workers in otherwise unconnected groups of people. Opportunities exist for organizations to collaborate to reskill and re-employ workers at scale.

In July 2019, Mukesh Ambani's telecom network Reliance Jio announced a literacy program called "Digital Udaan" for first-time internet users in India. The Udaan program aims to train what it calls the "educated unemployed." The three-year-old telecom network, which has amassed more than 300 million subscribers, has partnered with Facebook to create what it calls the largest-ever digital literacy program, which offers audio-visual training in 10 regional languages. Reliance Jio said Facebook helped build and curate modules to train people in 200 cities and small towns across 13 states, with further plans to expand to more than 7,000 locations where millions of JioPhone and other first-time Internet users live.<sup>87</sup>

One startup with an explicit goal to use digital technology for upskilling is iMerit, where 50% of employees of its 2,000-strong staff are women, and 80% are from low-income backgrounds.<sup>88</sup> The company, backed by Khosla Impact and the Michael and Susan Dell Foundation, taps into an under-resourced talent pool and creates digital inclusion through giving them new digital skills required to function in the future technology-driven economy. These workers are trained to help client companies enrich and label data so as to achieve the best results from their algorithms. iMerit's work powers algorithms in various fields of artificial intelligence, including machine learning and computer vision, which then have applications ranging from training driverless cars to optimizing crop yields.<sup>89</sup>

## **MEDTECH**

Access to quality healthcare remains a challenge for many in India. In 2018, the Modi government rolled out Ayushman Bharat Yojana, a government program to provide healthcare coverage for poor and vulnerable families, despite which, years of inadequate investment means that the public health system is severely strained, with hospitals and clinics typically ill-equipped and understaffed. According to the World Bank, India has less than one physician per 1,000 people, just half of the world average.<sup>90</sup> The situation is more acute in rural India. Almost 70% of India's population still lives in villages, often far from urban healthcare facilities.<sup>91</sup> However, about 40% of the country's health workers are practicing in rural areas.<sup>92</sup>

Thanks to the rapid growth of broadband coverage and mobile usage in India, telemedicine holds huge promise for bringing healthcare to the remotest corners in India, in terms of expanding the reach of affordable healthcare, helping trained medical personnel be more effective, and delivering medical services to the last mile. Technologies are not a silver bullet for social inclusiveness. Advanced medical technology often faces enormous challenges to take root and spread in rural areas due to low internet penetration and lack of affordability. Medtech also is unlikely to replace human doctors entirely. A McKinsey report estimated that the accelerated implementation of telemedicine could save India \$4 billion to \$5 billion a year by replacing some in-person visits to doctors to save travel time and costs.<sup>93</sup> But the report also noted that telemedicine requires the assistance of human healthcare workers to perform tasks which must be done physically, such as injections and drawing blood.

For medtech to thrive in rural communities, first, it has to be affordable to reach the poor. Second, it has to deal with the shortage of trained medical workers. It also has to be technologically viable in an environment where internet connectivity is weak, and where users have poor digital literacy. There is no doubt that the expanding availability of bandwidth and cheap data plans has played a big role in narrowing the urban-rural digital divide in India, but a significant gap remains. According to market research company Kantar IMRB, India had an average internet penetration rate of 40% in 2018, but the penetration in rural India was lower, at 25%, despite a jump from 9% in 2015.<sup>94</sup> By comparison, internet penetration in rural areas in China was much higher, at 38% in 2018.<sup>95</sup>

Some medtech companies have broadened the reach of healthcare in cities, but not many of them operate in rural India. Bengaluru-based Practo is an on-demand doctor consultation platform helping patients to schedule medical appointments with available doctors, without the hassle of waiting. Backed

by Chinese Internet giant Tencent and other investors, Practo had raised over \$250 million as of June 2019, making it one of the most well-funded healthcare startups in India.<sup>96</sup> Practo has announced plans to expand its footprint to 100 cities, including some lower-tier cities.<sup>97</sup> Nonetheless, its founder noted the challenges in catering for a two-tier India. He observed that while patients in urban India face issues like reliability, affordability and a shortage of trained medical personnel and equipment remain challenges for those in rural India.<sup>98</sup> For doctor-matching apps like Practo, their recipe for scaling up is dependent on several factors – high-speed Internet, customers’ purchasing power, and availability of medical service – none of which can be taken for granted in rural areas. Their reach is therefore confined to wealthy, tech-savvy urban dwellers, who are just unsure where to find good doctors.

Like Practo, home healthcare startup Protea Medical has adopted a big-city model. With presence in 24 Indian cities, its online platform matches healthcare professionals with patients and arranges house visits for them, especially for those who need assistance due to old age or disability.<sup>99</sup> It also provides services to a patient’s doorstep that range from collecting lab samples to renting medical equipment such as wheelchairs and ventilators. Protea has raised \$76 million in funding.<sup>100</sup> Despite efforts to provide health check-ups for the elderly in four cities,<sup>101</sup> Protea has yet to make a foray into rural areas as its service is seen as less affordable for the poor. The government’s launch of a national health insurance program last year appeared to be good news for Protea, but its CEO wrote that a lack of adequate coverage for out-of-hospital care by the program has prevented home healthcare services from penetrating into rural areas.<sup>102</sup>

Some smaller medtech startups address the problem of the lack of trained medical care in rural areas head-on. Neurosynaptic Communications’s ReMeDi has developed a medical diagnostics kit that empowers health technicians to act as proxies for doctors in some 2,000 clinics across 10 Indian states, as well as in Africa, Southeast Asia, and other South Asian countries like Bangladesh.<sup>103</sup> Its diagnostics kit, which was listed in the World Health Organization’s compendium of innovative health technology for low-resource settings, takes rural conditions into account in its design. For instance, it transfers in real-time health data such as blood pressure and pulse rate on low bandwidth to an offsite doctor for examination. It also works on just two watts of power, which it can draw from a computer USB port.<sup>104</sup> West Bengal-based startup iKure Techsoft has also developed portable solutions to extend healthcare services to nearly 3,900 villages in seven states.<sup>105</sup> Its diagnostic tool, called wireless health incident monitoring system, can be loaded on a smartphone or tablet to help rural health workers analyze patients’ information for health screening and early detection of diseases. Equipped with such data, iKure works in partnership with nongovernmental organizations and research institutes to analyze disease trends and design prevention strategies in areas concerning sanitation, hygiene, and nutrition.<sup>106</sup>

Considering that digital illiteracy is still a problem in rural villages, Karma Healthcare’s e-Doctor clinics operate with a combination of human touch and digital connectivity via an offline and online model. A patient entering the clinic is greeted by a nurse who speaks the local language to talk to patients about symptoms and facilitate a video consultation with doctors. With clinics in rural areas in Haryana and Rajasthan, Karma’s service covers 350,000 residents and targets a pan-India footprint by 2025.<sup>107</sup> Apollo Hospitals, one of India’s largest healthcare providers owning a chain of hospitals, pharmacies, and a health insurance business, has also made a foray into rural areas. It has built a network of some 60,000 teleclinics in rural areas, where patients can video chat with doctors while health workers help to take vital signs such as blood pressure.<sup>108</sup> Its electronic intensive care unit (e-ICU) service also allows smaller hospitals in remote areas to connect to the system so that critical patients can be monitored and given treatment advice by specialists in big cities.

Access to vaccines remains a challenge in rural India, partly due to the absence of a refrigerated supply chain to keep vaccines cool. A 2018 national survey showed that seven out of 10 children in the country failed to get timely immunization and were therefore vulnerable to diseases.<sup>109</sup> Drones could help solve some of these logistical challenges. Timothy Reuter, Head of Drones and Tomorrow’s Airspace at the

World Economic Forum, has suggested that drones can be used to bring vaccines to rural India, following successful examples in Africa.<sup>110</sup> Zipline, a U.S.-based startup, is making drone flights each day to deliver blood supplies to remote areas in Rwanda and Ghana.<sup>111</sup> While using drones for last-mile logistics is still very much a budding concept in India, Bengaluru-based Redwing Labs has secured pre-seeding funding to turn this into reality, through the launch of a drone delivery service for medical products in hard-to-access rural areas. Its co-founders have earlier developed drones that can deliver blood in a lightweight container with a gel ice pack after a request is made via SMS or messaging apps by rural health workers.<sup>112</sup>

Technological innovations have pushed boundaries of healthcare provision. However, investors and proponents of medtech should also beware of the ethical and legal challenges involved. The rise of medtech applications in India has raised concerns over data privacy and how technology platforms will act to ensure the security of patients' health data, which will likely be of great interest to third parties including advertisers and insurers. One example is the government's plan to unify the country's fragmented health system into a single electronic database of patients' records.<sup>113</sup> Potential benefits include giving healthcare providers better access to patients' medical history to improve diagnosis. Health officials will be able to implement more targeted policies when equipped with big data. However, critics have been worried that linking the platform with the government's wider digital infrastructure, including the Aadhaar ID system, will open the door to more data breaches.<sup>114</sup> This can be attributed to the government's less-than-satisfactory record on data protection. A state health department in India left medical records of 12.5 million pregnant women available online without a password. The leaky database was spotted during a security audit by a German researcher in March 2019. Despite being alerted to the privacy breach, the department took three weeks to remove sensitive patients' data related to abortion and pregnancy complications.<sup>115</sup>

## LIMITATIONS OF DIGITAL TECHNOLOGY-BASED SOLUTIONS FOR INCLUSION

The advent of 5G network technology, beginning with trials due in late 2019, opens up new possibilities for digital technologies to touch more sectors and meet the needs of broader populations in India. Vigorous public debate in India over whether Chinese provider Huawei Technologies, the world's biggest 5G equipment maker, should be invited to bid on 5G cellular network trials, has also brought the issues of data privacy and security to the fore, underscoring their importance.<sup>116</sup>

The issue of individual control over data is of great importance worldwide. India is still formulating its data privacy laws. Although Aadhaar does not collect data, its central database is nonetheless susceptible to data breaches. Examples of data leakage include fraudulent websites that have popped up disguised as official websites, phishing people for their personal information, and the fact that the Aadhaar card, when used simply as a photo ID, becomes vulnerable to being duplicated or faked because it lacks security features like a microchip or hologram.<sup>117</sup> Ram Sewak Sharma, chairman of India's telecom regulator and the first director general of the UIDAI, tweeted his Aadhaar number to the general public, and dared people to "show me one concrete example where you can do any harm to me." Hackers were able to use it to find his personal information and to transfer Rs. 1 to his UPI account, as a symbolic demonstration of how easy it was to do so.<sup>118</sup> One hacker managed to create a fake Aadhaar card which was accepted as genuine by Amazon and Facebook, according to researchers at the University of Washington.<sup>119</sup>

India currently does not have a data protection law, nor does it have a data protection agency, according to Privacy International, a non-governmental organization. Discussions over the direction of data privacy legislation are ongoing. One question raised was whether it was constitutionally valid to demand that Aadhaar be required as ID, with the larger question centering on whether the government could withhold services from those who didn't have Aadhaar or didn't wish to use it.<sup>120</sup> Another con-

cern was the risk of data theft. In January 2018, a reporter was able to buy a bootlegged database with data on 1 billion people for Rs. 500 (around \$8).<sup>121</sup> These privacy concerns ultimately rose to the level of India's Supreme Court. Its ruling, in September 2018, was the result of more than two dozen separate cases filed on legal, technical, constitutional, and right-to-privacy grounds.<sup>122</sup>

The Supreme Court's ruling, in September 2018, upheld the constitutional validity of the use of Aadhaar by government agencies in the administration of welfare payments, subsidies, and taxes, but disallowed its use in the private sector.<sup>123</sup> Because the private sector ban conflicted with policies to encourage financial inclusion, the RBI allowed the use of Aadhaar for e-KYC by entities regulated by it, with the consent of the Aadhaar number holder. This means banks can open instant bank accounts using e-KYC based on Aadhaar authentication.<sup>124</sup> The Supreme Court's ruling also says that private sector services may not be withheld from those refusing to use Aadhaar as proof of identity.

The decision threw a spanner into the works for many companies that had benefitted from the time-and-money-saving e-KYC function for customer acquisition. Non-bank financial services companies were at first barred from using Aadhaar's capabilities but were eventually granted permission to use offline authentication for e-KYC. The Aadhaar and Other Law (Amendment) Bill, passed in July 2019, clarifies that this is the case, and that during this process individuals must give consent to Aadhaar being used and be informed of alternatives to sharing this information, and the financial services company may not collect, use, or store Aadhaar numbers or biometric information.<sup>125</sup>

Digital India is not a panacea for all of the country's problems. Technology-driven solutions, while powerful, do not solve the core of certain structural issues India faces, such as ingrained social biases hindering mobility. The nation still faces a huge gap between rich and poor, and centuries-old social inequalities based on caste and gender. Nor can such technologies discussed here fully offset ingrained economic impediments like the preferential treatment of favored businesses by government that hinders competition. India's digital strategy also has work to do to satisfy concerns about data security and privacy.

## CONCLUSION

India's action in ensuring its citizens have access to a reliable identity is aligned with the United Nations Sustainable Development Goals for 2030, which call for a legal identity for all. Digital technology is one avenue for improving economic and social inclusion for broader populations in India. Because of the universal digital identity through the Aadhaar system and India Stack, more people are able to have better access to government services, as well as those provided by financial and telecommunications companies. Digital technologies are also making inroads in tackling challenges in other key sectors of the Indian economy, including enabling the use of precision agriculture and better distribution of agricultural products, allowing curricula to reach students living outside urban areas and improving skill levels, and connecting medical professionals with patients in remote areas and improving the quality of care and medical supplies delivered.

As illustrated in the previous sections, digital technology companies are disrupting various sectors in India, serving populations and tapping into customer segments previously out of reach both to government agencies and businesses. Many of the developmental challenges that have been plaguing India, and in some ways holding back the country's ability to share the fruits of its economic growth more equally, can now be tackled in a transformational way via the use of digital identity and digital technology in various sectors. Business-driven solutions, in collaboration with governments and civil society, have found efficient ways to tackle challenges for India's bottom of the pyramid and drive economic and social inclusion, broadening access to basic services to citizens and contributing to more sustainable development.

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