Nir Kshetri
Torbjörn Fredriksson
Diana Carolina Rojas Torres

Big DATA & CLOUD COMPUTING FOR DEVELOPMENT

Lessons from Key Industries and Economies in the Global South

BIG DATA AND CLOUD COMPUTING FOR DEVELOPMENT

This book provides a framework for evaluating big data and cloud computing based on how they evolve to fit users' needs in developing countries in key areas, such as agriculture and education. The authors discuss how this framework can be utilized by businesses, governments, and consumers to accelerate economic growth and overcome information and communication barriers.

By examining the ways in which cloud computing can drive social, economic, and environmental transformation, readers gain a nuanced understanding of the opportunities and challenges these technologies offer. The authors also provide an authoritative and up-to-date account of big data's diffusion into a wide range of developing economies, such as Brazil and China, illustrating key concepts through in-depth case studies. Special attention is paid to economic development in the context of the new Sustainable Development Goals formulated by the United Nations, introducing readers to the most modern standard of economic evaluation.

Students of information management, entrepreneurship, and development, as well as policy makers, researchers, and practitioners, will find *Big Data and Cloud Computing for Development* an interesting read and a useful reference source.

Nir Kshetri is a Professor at the University of North Carolina–Greensboro, USA, and a Research Fellow at the Research Institute for Economics and Business Administration, Kobe University, Japan. He is the author of *Global Entrepreneurship*, published by Routledge in 2014.

Torbjörn Fredriksson is the Head of ICT-related work for the United Nations Conference on Trade and Development in Geneva, Switzerland.

Diana Carolina Rojas Torres is an Assistant Professor of Entrepreneurship and Innovation at Universidad de la Sabana, Colombia.

"This book is essential reading for anyone who is interested in the social side of big data and cloud computing, particularly in the developing world. At a time when stories about the promise and peril of new information technologies are front page news, Kshetri, Fredriksson, and Torres provide an indispensable guide that helps us separate facts from hyperbole."

Russell Funk, *University of Minnesota, USA*

"This remarkable book addresses an important area that many books on these topics don't cover, examining how cloud computing and big data analytics drive social, economic, and environmental transformation in developing countries and outlining unrealized opportunities and challenges in realizing them. Illustrated with case studies from several countries, the book is a valuable source of relevant information for researchers, students, practitioners, and policy-makers interested in embracing the cloud and big data for socio-economic progress in emerging markets."

San Murugesan, *Editor in Chief, IEEE IT Professional & BRITE Professional Services, Australia*

"This is an outstanding presentation of big data and cloud computing concepts, issues, opportunities, and challenges, including case studies and lessons learned from developing countries. It offers great inspiration, creativity, and cutting edge information which researchers, academics, businesses, and students will be pleased to read."

Tomayess Issa, *Curtin University, Australia*

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PREFACE AND ACKNOWLEDGMENTS

Big data (hereinafter: BD) and cloud computing (hereinafter: cloud) are likened and equated to the "Industrial Revolution" in terms of technological innovation, structural change, and opportunities for economic growth. BD and the cloud are diffusing at an explosive rate. As cross-cutting technologies, they are having a transformative impact on economies and societies. In some sense, some developing economies are likely to experience more dramatic and significant BD- and cloud-led socio-economic transformations. It is argued that the cloud is providing these economies with an opportunity to leapfrog and overcome barriers related to leveraging information and communications technology (ICT) for development. BD- and the cloud-related systems have been successfully deployed and are being combined with cellphones, blockchain, mapping applications, and other technologies to facilitate information flow, which has already led to some gains in economic productivity and social progress.

In light of the above observations, the major goals of this book are to: (a) document, evaluate, and provide an authoritative and up-to-date account of the diffusion pattern of BD and the cloud in the developing world; (b) review the theoretical rationales for and factors affecting the diffusion of BD and the cloud in the developing world; (c) explain and make sense of the BD- and cloud-related paradoxical policy practices observed in some developing economies such as Brazil and China; (d) evaluate the effects of BD and the cloud in key development areas; (e) investigate the links between formal and informal institutional factors affecting the diffusion pattern of BD and the cloud in the developing world; (f) articulate and show the importance of security, privacy, and intellectual property protection issues raised by BD and the cloud in the developing world; (g) develop systematic knowledge about the appropriateness and worthwhileness of BD, cloud, and mobile phone combination in the developing

world; (h) discuss implications of the findings of this book and make suggestions for businesses, governments, and consumers; (i) identify areas of research needed to improve our understanding of the diffusion and development patterns of BD and the cloud in the developing world; and (j) describe BD and cloud deployments in developing economies in the context of the new Sustainable Development Goals currently being formulated by the United Nations.

Undergraduate and graduate students, researchers from a wide range of disciplines (e.g., economics, business and management, international relations, computer science and engineering, sociology, political science, etc.) represent the primary audience groups for this book. The book is also useful for policy makers and practitioners such as IT professionals, information system developers, information security specialists, CIOs, CTOs, and business executives, who need an informed understanding of the BD and cloud industry and market in the developing world. However, anyone with a broad interest in world affairs would find the book a useful reading and reference source.

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Nir Kshetri, Torbjörn Fredriksson, and Diana Rojas

The views expressed in this book are those of the authors and do not necessarily reflect the views of the United Nations.

ABBREVIATIONS

ACCA	Asia Cloud Computing Association
ACE	Africa Coast to Europe
AfSIS	Africa Soil Information Service
AI	Artificial Intelligence
AIS	Automated Identification Systems
ALICE	A Large Ion Collider Experiment
ATLAS	**A T**oroidal **L**HC **A**pparatu**S**
AU	African Union
AWS	Amazon Web Services
B2B	Business to Business
BD	Big Data
BPO	Business Process Outsourcing
BSA	Business Software Alliance
BSE	Bombay Stock Exchange
CAGR	Compound Annual Growth Rate
CERN	Conseil Européen pour la Recherche Nucléaire
CESI	China Electronics Standardization Institute
CHPC	Centre for High Performance Computing
CIMI	Cloud Infrastructure Management Interface
CKWs	Community Knowledge Workers
CoD	Cash on Delivery
COSTECH	Commission for Science and Technology
CRM	Customer Relationship Management
CS2C	China Standard Software Company
CSA	Climate Smart Agriculture
CSP	Cloud Service Provider

CUO	Cloud User Organization
DMTF	Distributed Management Task Force
DOVEs	Driverless Operated Vehicle Environments
DSCI	Data Security Council of India
DST	Department of Science and Technology
EASSy	East African Submarine Cable System
EC2	Elastic Compute Cloud
ECPA	Electronic Communications Privacy Act
EHR	Electronic Health Records
EIA	Environmental Investigation Agency
EMR	Electronic Medical Records
EthioSIS	Ethiopian Soil Information System
FIP	Fair Information Practices
FTC	Federal Trade Commission
GBPS	Gigabits per second
GCC	Gulf Cooperation Council
GHGs	Greenhouse Gas Emissions
HIPAA	Health Insurance Portability and Accountability Act
IaaS	Infrastructure as a Service
IAMAI	Internet & Mobile Association of India
ICT	Information and Communications Technology
IDC	International Data Corporation
IGF	Internet Governance Forum
IoT	Internet of Things
IP	Internet Protocol
ISP	Internet Service Provider
IT&BPM	IT and Business Process Management
ITU	International Telecommunication Union
IUU	Illegal, Unreported, and Unregulated
IXP	Internet Exchange Points
KBPS	Kilobits per second
KENET	Kenya Education Network
LDCs	Least Developed Countries
M2M	Mothers-2-Mothers
M&A	Merger and Acquisition
MADEX	Mobile Application Data Exchange
MAMA	Mobile Alliance for Maternal Action
MBPS	Megabits per second
MFI	Micro-finance Institution
MIIT	Ministry of Industry and Information Technology
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MOOC	Massive Open Online Courses
NASSCOM	National Association of Software and Services Companies

NCSP	National Cyber Security Policy
NDRC	National Development and Reform Commission
NESAP	New Economy Skills for Africa Program
NIST	National Institute of Standards and Technology
ODCA	Open Data Centre Alliance
ODPS	Open Data Processing Service
OECD	Organization for Economic Cooperation and Development
OVF	Open Virtualization Format
PaaS	Platform as a Service
PII	Personally Identifiable Information
PNBL	Plano National de Banda Larga
PPP	Public–Private Partnership
PSMA	Port State Measures Agreement
RBI	Reserve Bank of India
RFID	Radio-Frequency Identification
RNP	Rede Nacional de Ensino e Pesquisa
SaaS	Software as a Service
SANReN	South African Research Network
SDGs	Sustainable Development Goals
SEO	Search Engine Optimization
SKA	Square Kilometre Array
SMEs	Small- and Medium-Sized Enterprises
SMS	Short Message Service
SOE	State-Owned Enterprise
SSA	Sub-Saharan African
STEM	Science, Technology, Engineering, and Mathematics
TCO	Total Cost of Ownership
TEAMS	The East African Marine System
TNC	Transnational Corporation
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
VATS	Value-Added Telecom Service
VC	Venture Capital
WEF	World Economic Forum
WHO	World Health Organization
WTO	World Trade Organization
YEAPI	Youth Employment Accelerator Program Initiative

PART I

Big Data and Cloud Computing in the Global South

Key Concepts, Issues, Opportunities, and Challenges

1

DIFFUSION OF BIG DATA AND CLOUD COMPUTING IN THE GLOBAL SOUTH

Facilitators, Inhibitors, and Consequences

1.1 Introduction

Big data (hereinafter: BD) and cloud computing (hereinafter: cloud) are likened and equated to the "Industrial Revolution" in terms of technological innovations, structural change, and the sources of economic growth.[1] The uses of these technologies by businesses, governments, non-government organizations, and consumers are rapidly increasingly in the developing world.

This book shows that the uses of BD and cloud technologies, often in combination with other technological applications, can support the implementation of the 2030 Agenda for Sustainable Development, and its seventeen different Sustainable Development Goals (SDGs).[2] Advancing on the capability of developing countries to take active part in the BD and cloud ecosystems will therefore become increasingly important for accelerating progress in various targets, whether related to fighting hunger, mitigating climate change, improving health and education, or boosting productivity.

The literature on BD and cloud computing has so far primarily focused on trends and developments in the advanced economies. This is only natural since this is where most action has been to date. However, as is showcased in this book, a growing number of interesting and creative ideas and techniques involving BD and the cloud are being developed and deployed throughout the developing world and in different contexts.

For example, an intriguing application of BD and the cloud has been in improving water supply availability and reliability.[3] The deployment of BD and the cloud has greatly empowered customers and forced water providers to be more accountable, efficient, and transparent. Tools and applications have been built to improve the performance of government agencies, water aid groups,

and other actors as well as to provide information directly to end customers. Various approaches have been used by a number of organizations involved in improving the water supply situation in the Global South. Some of them include the following.

In cities with irregular and intermittent water supplies, the start-up company NextDrop utilizes data gathered from cellphone users to predict when water would be available. Utility employees call NextDrop's voice response system when they open water valves. The system sends a text message to local residents 30–60 minutes before water delivery. Residents are contacted randomly by the system to verify the accuracy of the information that valve men provide. Updates from utility employees are used to generate Google Maps-based streaming visual data, which can be tracked by engineers to know valve status in real-time.[4] NextDrop charges the consumer Rs.10 (about US$0.16) per month. The service was started in 2011 and in the first five months it had over 10,000 customers.[5]

The NGO Water for People uses Google's data-tracking technology to assess the real-time performances and functioning of its water supply projects. Its cellphone-based app Field Level Operations Water (FLOW) helps to monitor the performance of water projects by providing a way to collect, manage, analyze, and display geographically referenced data. For instance, individuals on the ground can report information about broken water pumps.[6] Mobile devices are used to collect data and photos from water distribution points. They are then uploaded to a dashboard for real-time analysis. Data can be collected even in the absence of mobile connection. In such cases, information is automatically transmitted when the devices are connected. The data collected this way are combined with visual map-based reporting tools. As of 2015, over 200 organizations including UNICEF and Millennium Water Alliance were reported to use FLOW.[7]

Likewise, in the healthcare sector, take the case of mothers2mothers (M2M), a South African NGO. It is combining the cloud with database technology and mobile services to fight the transmission of HIV/AIDS from mother to child.[8] Using the cloud, M2M digitizes patient records and shares them with counselors across the M2M networks, consisting of over 700 sites in Sub-Saharan Africa. The patient records contain information on treatment plans and advanced reporting tools, which would allow M2M to respond quickly.

The use of BD and cloud solutions provides an opportunity to leapfrog and overcome barriers related to information and communications technology (ICT) infrastructure and use.[9] The advantages of BD and cloud solutions can be enhanced further by combining them with other technologies and tools such as mobile phones and mapping applications to facilitate the flow of information in a diverse range of economic activities.

In this chapter, we review factors that are driving the development of BD and cloud industries in the developing world, examine their potential impacts and look at the roles of businesses and policy makers in order to facilitate the

adoption and effective utilization of these technologies. We present a framework for evaluating the attractiveness of BD and the cloud with reference to the evolving needs, capabilities, and competitive positions of developing countries.

1.2 Definitions and Concepts

Before proceeding with the analysis, it may be useful to provide some clarifications on definitions and concepts that will be used throughout the book. This section explains what we mean by BD, the cloud, different kinds of cloud applications, the main stakeholders in the cloud ecosystem, and how the cloud and BD are related.

1.2.1 Cloud Computing and Cloud Services

Cloud computing has been defined by the US standardization body, the National Institute of Standards and Technology (NIST), as follows:

> Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.[10]

Cloud computing involves hosting applications on servers and delivering software and services via the Internet. In the cloud model, companies can access computing power and resources on the "cloud" and pay for services based on usage. This contrasts cloud computing from the traditional, ownership-based model of IT assets and resources. One way of describing cloud services is that they are services that are provided and used by clients "on demand at any time, through any access network, using any connected devices [that use] cloud computing technologies."[11]

There are different categories of cloud services and applications. The three types most commonly referred to are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) (Figure 1.1).

Infrastructure as a Service (IaaS): In IaaS, compute power and storage space are offered on demand. IaaS can provide server, operating system, disk storage, and database, among other things. One of the main advantages of IaaS is that it offers rapid elasticity and flexibility. Amazon.com is one of the biggest IaaS providers. Its Elastic Compute Cloud (EC2) allows subscribers to run cloud application programs. IBM, Vmware, and HP also offer IaaS. China's Huawei provides IaaS solution for operators, governments, and enterprises with data center IT infrastructure.

Platform as a Service (PaaS): Applications are developed and executed through platforms provided by cloud vendors. This model allows a quick and

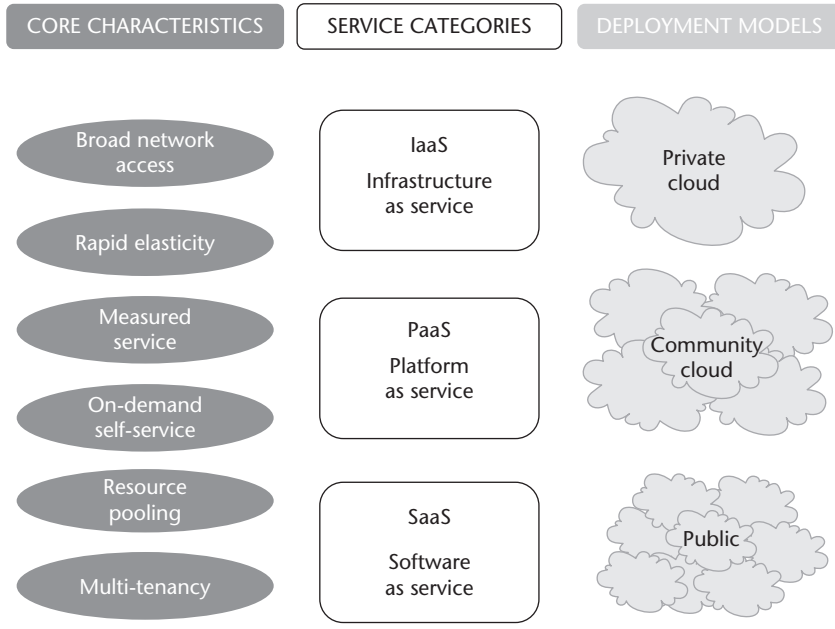

FIGURE 1.1 Characteristics and Types of Cloud Computing

Source: UNCTAD, Information Economy Report 2013: The Cloud Economy and Developing Countries (New York and Geneva: United Nations, 2013), 7.

cost-effective development and deployment of applications. PaaS is often used by application developers working on mobile applications. Some well-known PaaS vendors include Google (Google App Engine), Salesforce.com (Force.com), and Microsoft (Windows Azure platform). As another example, the US-based start-up, Cumulux, specialized on building, operating, and managing PaaS-based solutions, which was acquired by India's Aditi Technologies. Some facilities provided under the PaaS model include database management, security, workflow management, and application serving.

Software as a Service (SaaS): It is a software distribution model, in which applications are hosted by a vendor and made available to customers over a network. The provider licenses an application to customers for use as a service on demand. With the SaaS, users do not need to hire professional IT staff to install and use software. SaaS is the most widespread form of cloud service. Some well-known examples include Google email, Google Apps, and Salesforce.com's customer relationship management software. As a developing world-based example, MTN offers SaaS applications for micro-finance institutions.

Figure 1.1 highlights some of the characteristics of cloud computing, namely broad network access, rapid elasticity, on-demand services, pooling of resources, and multi-tenancy opportunities. It further recognizes that cloud services may

be provided in different configurations, involving private clouds (a proprietary resource for a single organization), public clouds (open to public use, such as webmail services), and hybrid clouds (mixing the two other deployment models).[12]

1.2.2 The Cloud Ecosystem and its Stakeholders

There are various stakeholders involved in what can be described as a cloud ecosystem (Figure 1.2). The UN Conference on Trade and Development identifies the following main players: Cloud Service Providers (CSPs), communications network providers and power suppliers, inter-cloud service providers, cloud service customers, advertiser.

1.2.3 Big Data

In order to define BD, we start with the technology research company Gartner's definition of BD, which are "high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making."[13] In this book's context,

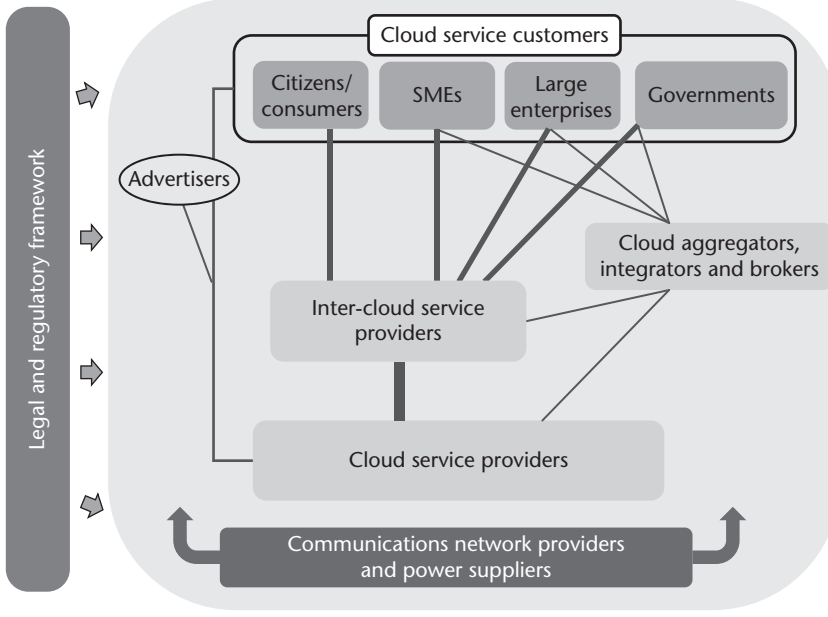

FIGURE 1.2 Main Stakeholders and Market Relationships in the Cloud Economy

Source: UNCTAD, Information Economy Report 2013: The Cloud Economy and Developing Countries (New York and Geneva: United Nations, 2013), 10.

we define BD as data sets that can provide insights into human well-being, which satisfy at least one of the following characteristics compared to data sets that have been traditionally used in developmental issues: (a) are of higher volume; (b) are of wider variety; and (c) enable to make decisions and act faster.

1.2.4 Developing Country

By developing countries, we mean low- and middle-income countries according to the World Bank's (2014) classification.[14]

1.2.5 The Relation between BD and the Cloud in Developing Economies: Each Driving and Feeding Off the Advancement of the Other

The US manufacturer of computer chips, Intel, observes that BD and cloud are converging, which makes BD analytics in clouds an appropriate option for organizations. The chipmaker argues that organizations increasingly need to develop a cloud-based BD in order to optimize the value of enterprise data.[15]

Thus BD and cloud computing play complementary roles. Each drives and feeds off the advancement of the other. While organizations often store their most sensitive data in-house, it makes more sense to locate huge volumes of less sensitive data that they own or that is generated by third-party externally in a cloud environment.[16] BD requires new processing and volume requirements, which translates into the need for additional infrastructure. Clouds offer flexibility and efficiencies for accessing data and generating insights from the data. For instance, clouds make it easier to scale up for processing power and storage.[17]

1.3 A Survey of BD and the Cloud in Developing Economies

The market research firm, Gartner, estimated the size of the global public cloud services market at US$131 billion in 2013.[18] It also noted that emerging economies in Asia (e.g., Indonesia and India, Greater China) and Latin America (e.g., Argentina, Mexico, and Brazil) are experiencing the highest growth rates for cloud services. Likewise, according to the research firm, International Data Corporation (IDC), worldwide revenues for BD will grow from US$122 billion in 2015 to US$187 billion in 2019. The IDC's study also found that the Middle East and Africa will be the fastest growing region (together with Latin America).[19]

Advanced countries still account for most of the global demand in BD and cloud computing. For instance, according to IDC, about 10 percent of Middle East and African servers were virtualized by the end of 2010. The proportion was 13 percent in the Gulf Cooperation Council (GCC) economies, compared

with 20 percent or higher in more developed regions.[20] The diffusion of the cloud has thus been slower in the Middle East compared to other economies with a similar level of economic development.

A fascinating aspect of this new technology is that countries across the world can participate in cloud computing platforms by developing new technologies, standards, innovations, and services. The cloud's open resources would allow developing countries to share the same resources and opportunities as players in the developing countries.[21]

The cloud is especially attractive if it is seen against the backdrop of scarcity of economic resources and a high propensity to share ICT tools.[22] For instance, in some African countries, although a mobile phone belongs to a person, it is regarded as a device for the community.[23] In the early 2000s, each phone in Bangladesh served an average of nearly seventy customers.[24] In this connection it is worth noting that the one laptop per child (OLPC) program probably is among some of the highly visible initiatives to improve ICT access in the global South. For an important reason, however, the OLPC program has fallen short in supporting the South's digitization initiative: it does not encourage sharing by multiple users. Despite optimistic promises of OLPC, the program thus has been far from successful.[25] In this regard, the first of the cloud's direct benefits is the possibility of sharing processors and data storage. That is, the cloud capitalizes on modern computers' unused capabilities and a single CPU can run multiple terminals used by several users.[26]

Cloud is also currently at the center of debate in the mitigation of greenhouse gas emissions. This issue is especially critical for developing economies given the serious air pollution problems facing them. ICT companies are estimated to account for 3 percent of global greenhouse gas emissions.[27] According to a McKinsey Quarterly (2010) report, in 2009, the world's 44 million data servers accounted for 0.5 percent of all electricity consumptions and their emissions were equivalent to those generated by Argentina or the Netherlands. The average data facility uses as much energy as 25,000 households and during 2000–2006, the amount of energy used to store and handle data doubled. The McKinsey Quarterly report noted: "Without efforts to curb demand, current projections show worldwide carbon emissions from data centers will quadruple by 2020."[28]

Some cloud-based applications are on the way to helping address environmental issues. For instance, Google's Earth Engine offers huge archives of satellite images data well as cloud computing power for free. Google teamed up with the US Geological Survey (USGS), NASA, and TIME to release the earth's images taken from space for more than a quarter-century.[29] Analysts expect that these measures may prevent deforestation.[30] In a related vein, executives at Microsoft and Facebook have said that the cloud could have positive environmental impacts. An Accenture study commissioned by Microsoft argued that companies could reduce data storage emissions by 30–90 percent by switching from on-site servers to data centers.[31]

Unsurprisingly, global corporations, local companies, and policy makers have started to devote more attention to the development of the cloud computing industry in the developing world.[32] For instance, IBM has launched cloud computing solutions and established data centers in a number of developing countries such as China, India, Vietnam, and Brazil. Other cloud players such as Microsoft, VMware, Salesforce, and Parallels are active in the developing world. Similarly, developing world-based firms have jumped on the cloud bandwagon. Cloud-related venture capital (VC) and other investments are also flowing into developing economies.[33] Overall, BD and the cloud have been a major focus of some businesses and government agencies in developing economies (Table 1.1).

1.3.1 An Example: The Case of Vietnam

While BD and the cloud are a recent phenomenon in developing economies, their growth rates and range of applications have been striking. The case of Vietnam is instructive in order to understand the key underlying mechanisms in the diffusion of BD and the clouds in the country.

BD and the cloud industries and markets in Vietnam are driven fundamentally by the government's belief that this technology would help build a skilled workforce and bring positive social and economic changes. A government agency uses the cloud approach to link other government agencies, universities, private-sector research, start-ups, and other organizations.[34] Vietnam started collaboration with IBM in 2007 on a pilot cloud program to make science and technology resources available to universities and research institutions. Other cloud players are also attracted by the dynamism of the Vietnamese economy. Computer Sciences Corporation (CSC), for instance, was planning to develop its Vietnamese operation as a center for cloud computing operational and support services, primarily for SaaS.

Universities, government ministries, and telecommunication vendors have adopted the cloud to create new services. Government institutions and universities use the cloud to develop education programs. The Ministries of Education and Training, Science and Technology, and Information and Communications have jointly developed cloud-based academic programs, which offer computing courses, free software tools, and business case studies. Vietnam National University (VNU) has also established a cloud platform.[35] IBM and VNU signed a Memorandum of Understanding about the use of cloud to build IT skills.

Vietnam Technology and Telecommunication (VNTT) offers the server or storage capacity and system capability for its clients, mainly SMEs. VNTT's clients can expand these services as their needs grow. VNTT also announced its plan to launch applications that are designed specifically for construction and another set of applications for real estate companies.[36]

1.4 Developing World-Based Firms in the Supply Side of BD and the Cloud

In light of the stereotypically different expectations that surround the developing countries' IT industry, they are playing crucial roles in the development of BD and cloud technologies. One obvious factor in the rapid growth of the BD and cloud industry and market in the developing world concerns the evolution of local entrepreneurial efforts.

Some highly visible examples of developing world-based firms supplying BD- and cloud-related services are presented in Table 1.2. At the same time, platforms provided by global cloud players such as Salesforce provide developing world-based developers with opportunities to build applications on the platforms.[37]

In 2009, CRL and AdventNet were among the high-profile Indian cloud providers (Table 1.2). Other Indian IT companies such as Tata Consultancy Services (TCS) and Wipro have entered the cloud market. Wipro has built a "private cloud" for its internal use. The company is also considering other services: public cloud, hybrid cloud, and helping independent software vendors design and implement SaaS.[38] It was reported that Infosys has dedicated about 175 engineers to identify better customer relations management and other areas in which cloud computing can help improve efficiency.[39] Likewise, TCS started the cloud through pilot projects in 2009.[40] As of February 2011, TCS had 130 clients using its cloud services, which is expected to increase to 1,000 by the end of the year. TCS promised that its cloud services would save 30–40 percent of IT spending for SMEs.[41] Other IT players, such as HCL Technologies and Bharti Airtel, have also embraced the cloud.

As noted above, the Indian company AdventNet's Zoho division operates a popular suite of web-based applications.[42] Likewise, Hyderabad-based Pressmart provides SaaS-based e-publishing and digitization services to the print industry. Pressmart solution can help firms deliver contents across multiple platforms such as Web, mobile, RSS, podcasts, blogs, social networking sites, articles, directories, and search engines.[43] In 2008, Pressmart received VC investment from Draper Fisher Jurveston and NEA-IndoUS Ventures. In 2009, the company launched a self-publishing tool called eMag Lite to publish an online magazine. As of 2009, the company was reported to have digital publications customers from forty-nine countries.[44]

In China, local players account for the bulk of cloud-related investments. The Guizhou province in Southwest China, particularly the capital Guìyáng, epitomize the development of BD and cloud industry and market in China and the increasingly prominent roles of local players. China Telecom, China Unicom, and China Mobile announced total spending of US$2.4 billion to build three Internet data centers in Guizhou housing two million servers.[45] Alibaba's cloud arm Aliyun has a contract to manage data of the provincial government of Guizhou.[46]

TABLE 1.1 Some Examples of BD and Cloud Computing Applications in the Developing World

BD/Cloud Application	*Examples*
E-commerce	• China: Wang Fu Jing has deployed several key BD and cloud services to share supply chain information and implement B2B e-commerce with suppliers.
E-education	• South Africa: The Computational Intelligence Research Group at the University of Pretoria uses cloud computing for the next-generation medical research. • East Africa: The Higher Education Alliance for Leadership Through Health (HEALTH Alliance), a consortium of seven universities, which includes universities in Kenya; Jimma University, Ethiopia; University of Kinshasa, Democratic Republic of Congo; Muhimbili University of Health and Allied Sciences, Tanzania; and Makerere University, Uganda, is working with industry experts to extend education through virtual computing labs that students access remotely. • India: The IIT Kanpur and other academic institutions use the cloud. • Vietnam: VNU's use of the cloud to build IT skills.
E-governance	• Vietnam: The Ministry of Education and Training, the Ministry of Science and Technology, and the Ministry of Information and Communications have jointly developed cloud-based academic programs, which offer computing courses, free software tools, and business case studies.
E-health	• China: The Guang Dong Hospital of Traditional Chinese Medicine has implemented a suite of healthcare data-sharing and analytics technologies.
E-banking	• India: ICICI's insurance arm has used Zoho's web-based applications to develop innovative services such as a personalized insurance for diabetes. • South Africa: Nedbank has automated business processes through cloud.
E-environment	• China: Universities' access to a supercomputer power to analyze climate data. • West Africa: The UK's Hadley Center for Climate Prediction and Research is negotiating with Amazon to sponsor a researcher for free access to cloud.
Industrial environments (e.g., *maritime industry*)	• Saudi Arabian Shipping Company Bahri uses BD to streamline operations and improve customer service. Its "Next Best Cargo" model suggests the most lucrative cargo that a charterer can consider.[1]

Retailing	• Alibaba uses WiFi sniffers, beacons, and other methods to collect data about store visitors for retail stores. Such data helps to determine traffic flows in stores. Here is how WiFi sniffers work: If a store visitor opens WiFi, her/his cellphone sends out a signal looking for available WiFi, which can be captured by the WiFi server. The information is a unique ID for a device. If a store visitor's device has an app with beacon capability, the signal sent to the server can capture the cellphone's location. As of the mid-2016, Alibaba was reported to develop about 20,000 consumer data models based on various behavioral and demographic profiles. Some models had as many as 1 million Chinese customers.[2]
Effective management of traffic congestion	• Southeast Asia's largest ride-hailing app, Grab, and the World Bank have teamed up to provide data to the region's transportation agencies, which is expected to fight traffic congestion. Grab and the World Bank provide the data for free. The initiative is called OpenTraffic. The Philippines Department of Transportation and Communications (DOTC) launched the program in Metro Manila and Cebu City in the mid-2016.[3] The open source tool converts GPS data from Grab's 250,000-plus drivers in six countries in the region into speeds, flows, intersection delays, and other traffic statistics. The data are anonymized, which help analyze peak hours for major roads and highways, identify areas most vulnerable to bad weather, and identify roads with the most accidents. Public agencies can use the data to manage travel demand. The data may also help cut travel time, design flexible routing schemes, and assign traffic personnel in areas that need the most.[4]

Notes

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TABLE 1.2 BD- and Cloud-Related Entrepreneurship of Developing World-Based Firms

Alibaba Group (China)	• March 2009: announced a plan to spend US$146 million in software development, marketing, and establishing cloud computing centers that provide SaaS to its customers, especially SMEs. • September 2009: announced the establishment of a new 500-staff subsidiary focusing on the cloud. • Mid-2009: Alisoft, Alibaba's software subsidiary, had captured more than 40% of the Chinese SaaS market. • Alibaba's BD ecosystem is arguably the strongest among the world's major players. It connects the whole value chain ranging from branding, broadcasting and, sales conversion.[1]
Baidu (China)	• In 2014, it signed a deal with the United Nations Development Program to build a BD lab together.[2] Its Beijing Big Data Lab seeks to find new applications for predictive modelling, machine learning and natural language processing in healthcare, disaster relief, and other areas.[3] • The first environmental protection solution launched by the lab is "Baidu Recycle," an e-waste recycling app. Users can take a photo of their electronic waste and estimated scrap price. As of 2014, users in Beijing and Tianjin could arrange e-waste pick-up, which was provided by a recycling partner. The service is expected to be expanded to more cities.[4]
China Mobile (China)	• 2014: established an R&D center in Suzhou with a plan to have a team of 3,000–4,000 researchers working on BD and the cloud.[5] • Mid-2016: had 11 million IoT users in automotive and industrial applications. The goal is to connect 5 billion devices by 2020.[6] • The cloud has *enhanced* advanced *mobile Internet* and helped to diversify demand. • June 2016: signed a US$1.53 billion agreement with Nokia to build a "cloud network." Nokia would build a new type of base station which uses multiple radio technologies. It would old technologies as well as the 5G networks and connected objects.[7]
Stefanini IT Solutions (Brazil)	• *Stefanini* is a Global IT Services provider, which had over 18,000 employees and offices in thirty countries across five continents in 2014.[8] • March 2009: announced an investment of US$218,700 to boost cloud computing product offering. • May 2014: invested in the creation of Datastorm, which is a new company dedicated exclusively to BD analytics. Datastorm combines skills in mathematics, statistics, technology, and business. Its multicultural team has professionals in diverse areas such as technology, design, math, and statistics.[9]

Infosys (India)	• Partnered with its major clients in cloud research. • Provides cloud computing-based services for the auto sector. • September 2014: Announced a partnership with Huawei to jointly offer cloud, BD, and communication solutions. The partnership combines Huawei's cloud infrastructure and Infosys' IT service expertise.[10]
Computational Research Laboratories (CRL) (India)	• A lab run by the Tata Group. • March 2008: Yahoo signed a research pact with CRL to support cloud research. • CLR would provide EKA supercomputer, which was the world's fourth fastest in March 2009.
AdventNet (India)	• Zoho division operates a popular suite of web-based applications. • Zoho had over 1.5 million users in March 2009, 2 million in September 2009 (400,000 users, 20% of total, in India and China). • The ICICI bank's insurance arm uses Zoho's applications to develop innovative services such as a personalized insurance for diabetes. Premiums are adjusted depending on how well policyholders stick to a fitness plan.
Mediatrac (Indonesia)	• Collective Intelligence Agriculture (CI-Agriculture), a subsidiary of Mediatrac, has developed precision farming techniques, which is adapted to the Indonesian context.

Source: Nir Kshetri, Cloud Computing in the Global South*:* Drivers, Effects and Policy Measures, *Third World Quarterly* (2011) 32(6), 995–1012.

Notes

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What is even more striking is that Chinese BD and cloud players are making significant investments overseas. Aliyun opened its first overseas data center in the USA in 2015.[47] In 2015, the Alibaba Group announced an investment of US$1 billion in cloud computing globally. The plan included the establishment of data centers in the Middle East, Japan, and Europe. In May 2016, the Alibaba Group teamed up with Japan's SoftBank Group to form a cloud computing service venture—SB Cloud Corp—targeting Japanese customers, which range from start-ups to global organizations.[48] In April 2016, Alibaba acquired Lazada, which is Southeast Asia's largest e-commerce website. Lazada would use Alibaba BD and analytics services.[49]

Chinese IT players are emerging as increasingly promising challengers to Western firms. As of mid-2016, Aliyun was reported to have more than half a million paying customers for its cloud services. While cloud computing was only 4 percent of Alibaba's overall business as of 2016, it is estimated to exceed US$1 billion in sales by 2018.[50] As of 2015, Aliyun's value was estimated at US$22 billion.[51]

Likewise, the cloud has been a critical component of Huawei's enterprise business.[52] As of early 2015, Huawei had over 480 data centers worldwide, which included 160 cloud data centers.[53]

1.5 BD and the Cloud Industry and Market in Developing Economies: A Framework

As a visual aid, our proposed framework (Figure 1.3) explains contexts, mechanisms, and processes associated with the development of BD and the cloud industry in the developing world in terms of three interconnected flows. It schematically represents how the three components are related. Impacts of the cloud (right side of Figure 1.3) reflect the "value" created by the cloud, which are the ultimate objectives that policy makers want to accomplish. Cloud-related performances (the box in the middle) are actions of various economic actors that are instrumental in delivering the impacts of the cloud. Determinants (left side of Figure 1.3) are key factors that affect cloud-related performances. Let's take a look at each of the components in turn.

1.5.1 Impact

1.5.1.1 Operational Efficiency: Productivity and Efficiency Gains

Operational efficiency is related to the costs of accomplishing corporate functions. Anecdotal evidence from China, India, and South Africa indicates that the adoption of BD and the cloud may lead to productivity and efficiency gains. As noted earlier, cloud has enabled some South African call centers to increase productivity by 20 percent.[54] The Indian cloud provider, Netmagic, reported

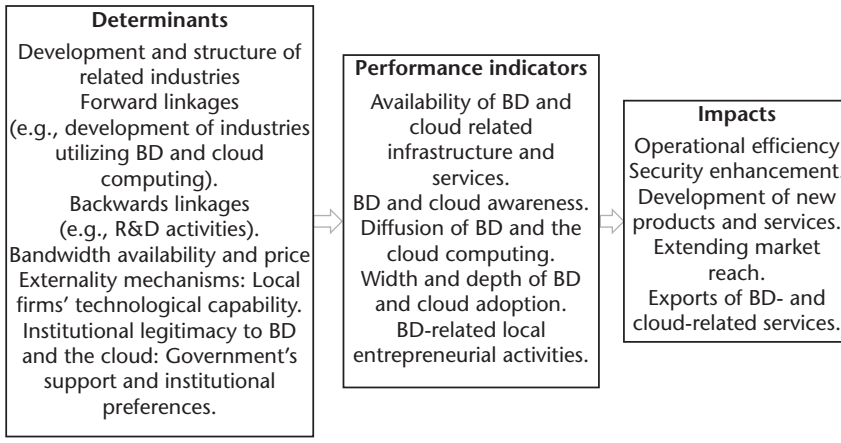

FIGURE 1.3 A Framework for Big Data and Cloud Computing Related Indicators in Developing Countries

Source: Adapted from Nir Kshetri, Cloud Computing in the Global South: Drivers, Effects and Policy Measures, *Third World Quarterly* (2011) 32(6), 995–1012.

that the company's cloud services helped its clients cut costs by 25–30 percent.[55] Microsoft claimed that its cloud services offered in India would help reduce IT costs by 10–50 percent.[56] Likewise, the cloud-based model has helped Chinese software start-ups access to infrastructures and data centers and utilize virtualized computing resources, which has led to a reduction of the upfront investments and product development costs.

Indian banks such as HDFC, ICICI, Kotak Mahindra Bank, ING Vysya Bank, and Citibank are using BD to enhance operational efficiency. For example, HDFC bank processes loan applications without human intervention. It was reported that it resulted in the bank's personal loan business growth by 30 percent.[57] It was reported that the State Bank of India (SBI) had hired sixteen statisticians and economists in 2014 to develop and implement its BD strategy. As of 2015, the bank had 170 terabytes (TB) of data and daily transaction data of about 4 TB was being added. It had over 200 million savings accounts.[58] The bank was reportedly studying cities in which colleges show the highest rate of delinquencies in student loans, the locations where branches and ATMs should be located, and the optimum amount of cash that ATMs should carry.[59]

1.5.1.2 IT Security Enhancement

Most organizations in the developing world have weak cyber-defense mechanisms. In 2002, North America accounted for 58 percent of the global IT security market.[60] An estimate suggested that in 2006, about three million of Brazil's SMEs lacked anti-virus software in their PCs.[61] Likewise, in 2009, 60

percent of Kenyan banks were reported to have insecure systems.[62] The cloud has a possibility to enhance data security for such companies. In this regard, the concept of "hollow diffusion" of e-commerce can be helpful in understanding weak defense.[63] Many companies in developing countries lack the technological and human resources to focus on security. "Hollow diffusion" can take place in human terms (lack of skill and experience) as well as in technological terms (failure to use security products). Some ISPs in industrialized countries block contents originating from problematic networks in developing countries.[64]

It is being increasingly recognized that despite its potential to provide low-cost security, organizations may increase risks by storing sensitive data in the cloud.[65] The cloud is thus a double-edged sword from the security standpoint. Yet many of the reasons why businesses and consumers in the global South face various security risks suggest that the cloud may offer more security-related benefits to them than their counterparts in the global North. Especially, the cloud's economies of scale allow a business model in which third parties can integrate applications into the cloud to provide a cost-effective security.[66] Delivery of security on the cloud can address some of the human (e.g., problems to install and maintain software) and technological issues, and may strengthen the defense mechanisms.

1.5.1.3 Development of New Products and Services

The cloud has helped some firms in the global South to launch new products and services commercially. Zoho's applications are used by hospitals and banks in India to develop new products (Table 1.2). As another example of cloud use to develop new products and services, consider the Computational Intelligence Research Group at the University of Pretoria. As noted earlier, students in the university use the cloud to develop new drugs.

1.5.1.4 Extending Market Reach

BD and the cloud can extend the market reach of SMEs. For instance, industrialized world-based healthcare providers are increasingly offshoring services related to medical transcription, billing, and insurance claims teleimaging and telepathology to India. The business is currently dominated by big players such as Wipro and Teleradiology solutions. Cloud computing is likely to open the door for smaller Indian players to participate in the global healthcare offshoring industry, by reducing the need for upfront investments for small offshoring companies.

1.5.1.5 Exports of BD- and Cloud-Related Services

There has been some achievement on the export of cloud-related applications and services. Unbelievable as it may sound, some developing world-based

technology companies such as AdventNet have been exporting cloud-based applications (Table 1.2).

1.5.2 Performance

1.5.2.1 Availability of BD- and Cloud-Related Services

The diffusion of cloud in most developing economies has been hindered by the lack of availability of businesses supplying such services. These countries tend to lack market and infrastructures that control the availability of the cloud and thus multinationals such as IBM and Google are likely to enter much later in these countries.

1.5.2.2 Awareness of BD and the Cloud

Awareness is the first step in the cloud adoption process. As noted above, there has been a lack of awareness of BD and the cloud among some enterprises in the developing world.

1.5.2.3 Diffusion of BD and the Cloud

Diffusion measures the penetration level of the cloud or the number of organizations that adopt this technology. It can also be measured with specific cloud application such as number of users of Zoho's productivity tools or IBM's PangooSky platform.

1.5.2.4 Width and Depth of BD and Cloud Adoption

Obviously a higher cloud performance is achieved by wider and deeper adoption of the technology. Note that the width of BD or cloud adoption can be defined as the number of different uses (Table 1.1).[67] Similarly, the depth of BD or cloud adoption can be defined as the amount of usage of the cloud by businesses (e.g., frequency of software download from the cloud, amount of data stored on the cloud, etc.). At the firm level, the concepts related to width and depth can be further elaborated. For instance, a higher width of BD or cloud usage is associated with a greater number of employees in a company using these technologies for performing a particular function, and overall depth, which is related to the total BD or cloud usage.[68]

1.5.2.5 BD- and Cloud-Related Entrepreneurship

Cloud-related entrepreneurship can be defined as the enterprising cloud-related actions undertaken to generate "value, through the creation or expansion of

economic activity, by identifying and exploiting new products, processes or markets."[69] To capitalize on the cloud, developing world-based firms are gaining resources from internal and external sources and are integrating and rearranging them to enhance technological capabilities. In the context of a rapidly emerging and evolving industry such as the cloud, this process is also referred to as the development of dynamic capabilities, which is likely to help them "to match and even create market change."[70] For instance, developing world-based firms have intensified cloud research and are receiving VC investments.

Some developing economies have set forth an ambitious agenda on the BD front. For instance, China's goal has been to create ten global leading enterprises in the BD industry and 500 firms focusing on BD applications, services, and manufacturing by 2020.[71]

1.5.3 Determinants

In examining the factors that can help the cloud industry thrive (high performance and high impact), one would do well to recall the comment by Adams: "like fire technology depends on its environment to flare or die."[72] A technology's ecosystem and environment are influenced by numerous factors. First, the diffusion of a technology is influenced by the nature of domestic demands and inputs[73] such as consumer preferences, income, input, infrastructures, government regulations, and technological economies of scope (a function of experience with previous generations of technology). Second, the importance of industry structure has been emphasized in the literature.[74] Of special interest to this book is the development of related and supporting infrastructure such as access to broadband and PCs. Competition level, size, and distribution of cloud suppliers, as well as the nature and structure of related industries fall under this category. Finally, transfer and export conditions such as trade policy, export orientation of firms, strategic regulation, and market size also affect an industry's growth.[75]

1.5.3.1 Development and Structure of Related Industries

Development and diffusion of the cloud are tightly linked to the forward linkages (demand), backward linkages (supply), and horizontal or inter-sectoral linkages.[76]

1.5.3.2 Forward Linkages

The strength of forward linkages between the cloud and the rest of the domestic economy plays an essential role in determining the development of the cloud industry. For instance, in the VNTT example above, a lack of strong demand

from companies in the construction and real estate industries limits deployment of the company's cloud applications. The availability of e-governance services and solutions for businesses and citizens such as health care and education, permit, drivers' licenses, bills payment, land records and registration, e-tendering, e-tax file return, benefits determination and distribution would strengthen forward linkages. In China and India, the strong demand has helped create strong forward linkages for global and local cloud providers (Table 1.3).

1.5.3.3 Backward Linkages

The development of industries that supply various ingredients needed for the cloud industry helps to foster stronger backward linkages. In India and China, the R&D in cloud and development of the supercomputer industry has provided strong support for backward linkage (Tables 1.2 and 1.3).

1.5.3.4 Horizontal or Inter-Sectoral Linkages: Bandwidth Availability and Price

Cloud computing services require relatively high bandwidth to work well. Bandwidth unavailability is the most glaring shortcoming of most developing countries, especially in rural areas, which limits the diffusion of BD and the cloud in developing economies.[77] High bandwidth is especially important if data to be transferred include large files (such as high-quality multimedia content and videos). A major challenge in the developing world is thus to expand bandwidth and enhance access to reliable and affordable broadband connectivity.

1.5.3.5 Externality Mechanisms

Firms' technology-related behaviors have self-reinforcing effects. IT firms may generate externalities by making cloud-related specialized inputs and services available, forming a specialized "labor market"; and facilitating the exchanges and spillovers of information and technology.[78] These externalities, which originate from other firms in the same industry, are called MAR externalities.[79] MAR externalities represent the positive role of specialization on growth through knowledge spillovers.[80] There is also a possibility of "inter industry knowledge spillovers," [81] which are referred to as Jacobs externalities.

1.5.3.6 Local Firms' Technological Capability

Technological capabilities of some developing world-based firms have generated positive externalities to the local economy. Technological capabilities combined with low cost and experiences in serving the home market may allow

TABLE 1.3 Determinants of the BD and Cloud Industry in the Developing World

Determinant	*Mechanisms*	*Examples*
Development and structure of related industries	*Forward linkages*	• China: the government is planning to create a fully electronic predictive health information network, which would create demands for cloud-based services. • China and India: economies of scale in B2B e-commerce, supply chain management, and e-healthcare.
	Backward linkages	• China: cloud related R&D has helped the development of the cloud industry. 490 of world's top 500 companies have invested in China and have established over 1,160 R&D centers in the country. IBM computing centers in China, for instance, draw upon experts from IBM's R&D full-scale labs in the country, which are globally oriented and work on most advanced products.
	Horizontal or inter-sectoral linkages	• South Africa: high speed and low cost of bandwidth facilitated the development the cloud industry.
Externality mechanisms	Local firms' technological capability (MAR and Jacobs externalities)	• China's Alibaba and India's Infosys illustrate how local firms' specialization in various IT areas can contribute to the growth of the local cloud market through knowledge spillovers.
Institutional legitimacy	Government's support	• Vietnam: the cloud is driven fundamentally by the government's belief that it would help build a skilled workforce. • China: The cloud has a strong support from the government: substantial funds in its US$586 billion economic incentive budget.
	Institutional concerns	• Security issues are likely to be a big concern in authoritarian regimes. • BD and the cloud makes it easier for the government to spy on citizens.

them to develop value-creating strategies and to realize a significant share in the cloud market, especially in the home countries (Table 1.2).

Indian IT companies such as TCS, Infosys, and Wipro are today leading global IT players. Their specialization in IT sectors has generated Jacobs[82] externalities for the cloud. Some see India as an early cloud as the country's software companies had huge data-processing centers that big companies around the world used for on-demand computing.[83] In this case, the externalities can be considered as MAR externalities. In sum, some Chinese and Indian companies are in a good position to provide software and services that run on some of the dominant cloud platforms as well as to develop their own platforms, products, and services.

1.5.3.7 Institutional Legitimacy to BD and the Cloud

All economic phenomena have institutional components and implications.[84] Institutionalists have recognized that the success of an innovation is tightly linked to the context provided by institutions in an economy. By institutions, we mean "the macro-level rules of the game,"[85] which can be formal (e.g., laws and regulation) as well as informal (e.g., social norms and culture). Institutions provide the "cognitive, normative, and regulative structures"[86] that determine institutional preference for an innovation such as the cloud.

1.5.3.8 Government Policy and Support

The development of an industry such as the cloud is a function of the level of government priority set for this sector[87] and the focus of national industrial and technological policies on fostering and strengthening this sector.[88]

As reviewed above, government supports have stimulated the BD and cloud industry in Vietnam. Likewise in China, in 2012, the entire Chinese banking industry was estimated to have about 100 terabytes (100,000 gigabytes) of customer data. By March 2014, only the Industrial and Commercial Bank of China was reported to have 4.9 petabytes (4,900,000 gigabytes) of data.[89] A number of legislation changes in 2013 regarding use of customer data acted as a key force that drove banks, investment funds, and insurance companies to quick adoption of BD.

1.5.3.9 Institutional Concerns

The diffusion rate of an innovation is positively related to the innovation's compatibility with the social system.[90] In this regard, the cloud may face roadblocks in social systems with certain characteristics. Many are concerned about data privacy and security associated with unauthorized access and use of information stored in the cloud.[91] For example, an obvious danger of the cloud in an authoritarian

regime concerns the possibility that the government may intensify further controls on its citizens. Note that the cloud has been described as the ultimate spying machine.[92]

In a discussion of the institutional implications associated with the cloud, China deserves special attention. Among Chinese leaders, there are suspicions that the country is under cyber-attack from the USA. Computer hardware and software imported from the USA and its allies are subject to detailed inspection. Chinese technicians take control of such imports and resist or closely monitor if Western experts install them.[93] The Chinese government may not be comfortable with the idea of storing data on the cloud provided by foreign multinationals.

1.6 Conclusions and Some Unanswered Questions

The foregoing discussion helps us understand the contexts, mechanisms, and processes associated with the development and deployment of BD and the cloud in the developing world. While it took many years and large investments for the developed world to acquire infrastructure, data centers, and customized application software, cloud computing has made it possible for developing world-based organizations to access them more easily.[94]

The above discussion also indicates that BD and the cloud may increase the effectiveness and enrich the uses of other technologies, such as mobile telephony. There are two interrelated reasons why this is likely to happen. First, recent developments in the cloud have made it possible for less sophisticated mobile phone owners based in the global South to access and use various applications in the cloud. Thanks to recent developments, any mobile phone that is capable of running a web browser can access mobile applications in the cloud. This means that even low-cost phone users in the developing world can tap into applications that are currently accessible only to smart phones. Second, consumers in the global South are using increasingly sophisticated mobile devices, which can accelerate the diffusion of mobile-based cloud and enrich the experience of cloud use. For instance, the smartphone penetration rate in China in 2015 was estimated at 38.6 percent or a total of about 525.8 million.[95]

Regarding the potential and impact of the cloud in the global South, however, there is a need for more empirical studies. Some analysts suggest that developing countries are likely to be attractive markets for cloud computing services and this technology will make "Health Care 2.0," "Banking 2.0," and "Education 2.0" realities in these countries.[96] While BD and the cloud are diffusing rapidly in developing countries, it is not clear how these possibilities are being realized.

In theory, it should be easier for developing economies to catch up with the West as the cloud allows them to have access to the same IT infrastructure, data centers, and applications. For instance, the cloud would help developing world-based researchers to access to the data required for research as

well as telecommunications and computing infrastructures.[97] As to the potential of BD and the cloud in the developing world, the first observation is that these technologies reduce infrastructure costs and level the playing field for small- and medium-sized enterprises (SMEs).[98] For instance, companies such as Alibaba provide cloud and BD analytics services to small vendors. The second commonplace observation is that, unlike client-based computing, which requires the installation and configuration of software and updates with each new release as well as revisions of other programs with every update, software on the cloud is easier to install, maintain, and update.[99] This benefit is especially important for rural users with little IT training.[100] Third, cloud services provide an organization with the flexibility of scaling up the use if the demand increases.[101] This approach requires low upfront investment and is thus ideal for SMEs. Fourth, proponents of the cloud also cite observers who argue that as software becomes free via web-based applications or available in SaaS, software piracy is likely to reduce.[102] It is argued that the cloud allows businesses and consumers to use more secure systems, which is likely to reduce the incentives to use pirated software.[103]

A final observation is that the cloud enables business models in which third parties can provide a cost-effective security for SMEs.[104] However, these observations may have underscored how economic and institutional problems remain central to the diffusion of ICTs in the developing world. For instance, while BD and the cloud have a big potential to transform economic, social, and political institutions in developing countries, they have not yet been sufficiently exploited there.[105] There is little, if any, empirical evidence, which shows how effectively these theories, ideas, and speculations can translate into practice in developing countries.

The as yet unanswered questions thus include, as follows: (1) What factors drive the diffusion of BD and the cloud in developing countries? (2) What are the potential economic, social, and political impacts of these technologies in these countries? (3) What roles can businesses and policy makers play to facilitate the adoption and effective utilization of BD and the cloud?

1.7 Roadmap to the Remainder of This Book

The remainder of this book is divided up as follows. Chapters 2 and 3 discuss the institutional and technological dimensions associated with BD and the cloud in developing countries. In Chapters 4 through 6 we analyze the development and deployment of BD and the cloud in selected key industries and economic sectors, such as education and R&D, primary sectors, and e-commerce. In Chapters 7 through 10, we look at BD and cloud deployment in some regional and national economies, notably Sub-Saharan Africa, India, China, and Brazil. In Chapter 11, we discuss key findings, provide implications, and conclude the book with some goals for the future.

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2

THE ROLES AND SIGNIFICANCE OF MOBILE PHONES IN THE VALUE PROPOSITION OF BIG DATA AND THE CLOUD

2.1 Introduction

The use of mobile devices, rather than personal computers, to access BD- and cloud-based applications stands out as a particularly appealing and promising choice for developing economies, especially the least developed countries (LDCs). Among the most compelling reasons is that less than a third of the population in developing countries owned a PC in 2015, compared with a cell-phone subscription penetration of 92 per 100 inhabitants (Table 2.1). In India, for instance, mobile phone subscriptions reached one billion in 2015, which is 83 percent of the country's population.[1] On the other hand, India's PC penetration in the same year was estimated at 10 percent.[2] Indeed, more people worldwide have a mobile subscription than have access to a clean toilet, electricity, or clean drinking water.[3] Unsurprisingly, there are already many successful examples of projects involving BD- and cloud-based mobile computing solutions in developing economies. This chapter focuses on more general issues of BD, the cloud, and mobile phone combination to deliver value to end-users.

In order to illustrate the above point, consider the use of mobile computing solutions to deal with the shortage of clean drinking water. It is estimated that women and girls in developing countries spend between three minutes to three hours per day in collecting water for drinking, cooking, cleaning, laundering, etc.[4] Reducing this time would give them more time to spend on productive economic and social endeavors such as agriculture and farming-related activities, focusing on maternal and child-health-related issues and attending school. Various approaches have been reported involving the cloud and mobiles in combination with mapping applications and other technologies to facilitate information flow and to improve water supply availability and reliability.[5]

TABLE 2.1 Key ICT Indicators for Countries with Various Levels of Economic Development

	Fixed-Telephone Subscriptions	*Mobile-Cellular Telephone Subscriptions*	*Active Mobile-Broadband Subscriptions*	*Fixed Broadband Subscriptions*	*Households with a Computer*	*Households with Internet Access*	*Individuals Using the Internet*
Developed	39	120.6	86.7	29	80.8	81.3	82.2
Developing	9.4	91.8	39.1	7.1	32.9	34.1	35.3
LDCs			12.1	0.5		6.7	9.5
World	14.5	96.8	47.2	10.8	45.4	46.4	43.4

Source: ITU (2015).

An innovative use of BD- and cloud-based mobile computing solutions has been in minimizing water loss due to leaky pipes. One estimate suggested that 60 percent of water worldwide is lost due to leaky pipes.[6] It should therefore come as no surprise that improving water management is a key target under the Sustainable Development Goals. Target 6.4 says: "By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity."[7]

In May 2013, IBM and South Africa's City of Tshwane teamed up to launch "Water Watchers," a mobile application that can be used to report water-related issues. The app's users take a picture that shows a water-related problem and answer three related questions. The data is then uploaded in real-time on a cloud server. The information generated can be expected to identify a water "leak hot spot" map.[8]

EpiSurveyor, which is among the most popular and publicized tools for collecting and analyzing data, has been used in improving water supply availability and reliability. This tool was developed by DataDyne, which is a non-profit organization. Aquaya.org employs this application to help operators of rural water systems submit water quality data to their managers.[9] It has also been used in health care, agriculture, business, research, and conservation.[10] In 2008, the World Health Organization (WHO) and the Kenyan health ministry used EpiSurveyor to fight polio. Health workers used EpiSurveyor to track an emergency vaccination campaign, which helped to stop a potential polio epidemic.[11] The survey forms can then be downloaded to a mobile phone, which can be used to collect and upload data in real-time to an EpiSurveyor account.[12] It was reported that as of April 2012, EpiSurveyor was reported to have about 8,000 users in over 170 countries such as Kenya, Malawi, Tanzania, Zambia, India, Pakistan, the Philippines, Nicaragua, Brazil, and Indonesia. The WHO's African Regional Office (WHO/AFRO) has implemented EpiSurveyor in fifteen Sub-Saharan Africa (SSA) countries.[13] This Java-based application is a free, web-based software for data collection which can be used on number of phone brands.[14]

Other applications involving BD- and cloud-based mobile computing solutions have helped to deal with developmental, political, and social issues such as improving health outcomes, fighting corruption, and reducing poverty. For instance, such solutions have transformed health care by driving down costs, changing workflow, improving business continuity, and making an adequate provision for disaster recovery.[15] In SSA economies, BD- and cloud-based mobile computing solutions have enabled a quicker response in curing diseases such as HIV infection/AIDS and improved early warning and faster response to crises such as an outbreak of malaria. In the Millennium Village-related projects, which covered more than twenty SSA countries as of early 2014, BD- and cloud-based mobile computing solutions were being utilized in health care,

education, and other social infrastructure and services for the people. For instance, community health workers in the MVPs in Ethiopia and other countries use BD- and cloud-based mobile computing solutions to deliver healthcare services directly to households and collect health information for improved monitoring.

BD- and cloud-based mobile computing solutions have boosted productivity of traditional sectors such as agriculture and farming as well as that of enterprises in the modern sector. For instance, the mobile application, iCow, which helps small-scale Kenyan dairy farmers track and manage cows' fertility cycles, has helped to increase milk production by 2–3 liters per cow per day.[16]

No less important is the role of the data and information generated through BD- and cloud-based mobile computing solutions in the creation and functioning of the market. The data and information play an especially important role in developing countries because factors such as underdeveloped intermediary institutions and informational opaqueness of small and young firms have acted as a barrier to the functioning of markets in these countries.[17] For instance, as of September 2013, the information created by the cloud-mobile platform, Agri-Life, which provides financial institutions and suppliers "near-real-time information" on farmers' ability to pay for services,[18] facilitated over US$2 million in revolving credit lines to about 120,000 small farmers in Kenya and Uganda.[19]

2.2 The Deployment of BD- and Cloud-Based Mobile Computing Solutions

BD- and cloud-based mobile computing solutions in developing economies are supplied by local as well as foreign firms. Regarding the SaaS model, unlike client-based computing, cloud-based software is easier to install, maintain, and update and does not require a huge initial capital commitment. For instance, merchants using Kopo Kopo software (Table 2.2) do not need to worry about installing and configuring the software and updating it with each new release, as well as revising other programs with every update and can pay on a per usage basis.

The cloud reduces infrastructure costs, which can be illustrated with the deployment of PaaS. For instance, the South African start-up, Nomanini sells a "business in a box," a cloud-based mobile prepaid airtime machine, to small informal entrepreneurs, which allows them to set up a "mini-business." It is called Lula (meaning "easy" in Zulu language), which is especially useful for providing services to support individuals engaged in small business and informal economic activities such as taxi drivers and "on the go" vendors. Lula generates and prints codes which people purchase to add minutes to their mobile phones. Lula runs on Google App Engine, which is the same infrastructure that powers Google's own applications such as Google Calendar, Gmail, and Google Docs. That is, Google provides the framework and storage and manages servers for

Lula. Google also provides services to software applications associated with Lula beyond those that are available from the operating system (known as middleware). In addition, Google provides runtime-related services such as supporting the execution of programs required to print vouchers using Lula. Nomanini's goal is to reach one million informal market merchants by 2020. That also allows the company to build up a huge amount of data about the informal markets.[20]

An IaaS model allows delegating functions such as storage and computing to the cloud provider. For instance, according to biNu's developers, by moving much of the processing to the cloud, biNu works ten times faster than regular mobile web browsers. In this way, biNu creates a virtual "smartphone in the cloud" for a user.[21] It makes graphics and text on the cloud and the data is sent back to the phone as tiny images. An advantage of sending the data as images is that the text can be displayed in any language irrespective of the language a phone is programmed to handle. Each image consists of only one or two packets of data of less than one kilobyte (KB) each. Information is not sent twice. The servers remember the information that is sent before and provide only new instructions that are needed to change the content on the screen.[22] The cloud also provides the flexibility of scaling up uses when the demand increases.

2.3 Appropriateness, Effectiveness, Feasibility, and Worthwhileness of BD- and Cloud-Based Mobile Computing Solutions in the Developing World

The high penetration of mobile phones in developing countries makes BD- and cloud-based mobile computing solutions among the most appropriate and useful technologies. The least gap between developed and developing countries is observed for mobile subscriptions compared to most ICTs, which makes BD- and cloud-based mobile computing solutions particularly promising. For instance, in 2016, mobile phone (non-broadband) subscription was only 34 percent higher in developed countries as compared to developing countries. On the other hand, mobile broadband subscription, fixed broadband subscription, and fixed telephone subscription in developed countries were 221 percent, 367 percent, and 428 percent, respectively, as high as in developing countries (Figure 2.1). Likewise, the proportion by which developed countries' Internet and computer penetrations exceeded those of developing countries ranged from 149 percent to 177 percent in 2013 (Figure 2.2).

The cloud has increased the effectiveness and enriched the uses of cellphones. New technological developments, related to cellphones and the cloud, are contributing to a more rapid diffusion of BD- and cloud-based mobile computing solutions. First, less sophisticated cellphones are now "cloud-ready" as a result of recent developments. A cellphone capable of running a browser can access a number of mobile cloud applications. Low-cost phone users can thus tap into

TABLE 2.2 SaaS, PaaS, and IaaS for Mobile Phones in Developing Countries

Cloud-Based Application	*Explanation*	*Some Well-Known Examples*	*Examples of BD- and Cloud-Based Mobile Computing Solutions from Developing Countries*
SaaS	A software distribution model, in which applications are hosted by a vendor and made available to customers over a network. Clients can access them from a web browser and thus do not need to install or download anything on their devices. It is considered to be the most mature type of cloud computing.	Google email, Google Apps, Salesforce.com's customer relationship management software.	Kenya's Kopo Kopo delivers software to SMEs via the web, which allows accepting and tracking purchases made with mobile money. It can be accessed by PC and Android phones. The software is capable of seamless incorporation of transactions into accounting software such as Quickbooks and its management. SMEs can also analyze buying trends, and employ SMS to communicate with customers (e.g., upcoming sales). By the end of 2013, over 10,000 retail merchants in Kenya used Kopo Kopo, which made it Safaricom's largest merchant aggregator and among the largest in SSA.
PaaS	Customized applications are developed quickly and in a cost-effective manner and executed through a platform provided by a vendor. The client manages the applications and data. Some facilities provided under PaaS model include database management, security, workflow management, and application serving.	Google App Engine, Salesforce.com (Force.com), Microsoft (Windows Azure platform).	Nomanini's Lula is a US$200 portable orange device, which acts like a small digital vending machine for prepaid vouchers for airtime credit. Nomanini deploys codes to Google's data centers. It runs on Google App Engine, which processes a request, and a voucher is printed in a few seconds. In November 2012, 40,000 people bought airtime through Lula.[3]

IaaS	Computing power and storage space are offered on demand. That is, a cloud provider installs the client's virtual server on its infrastructure and charges a rent based on the resources used. IaaS can provide server, operating system, disk storage and database, among other things.	Amazon's Elastic Compute Cloud (EC2), IBM, Vmware, and HP.	The nonprofit organization Worldreader makes free books available to kids in SSA. The books can be accessed by low-end mobile devices and older 2G mobile networks. A free mobile software platform biNu is used to access the books. biNu moves much of the processing to the cloud instead of doing it on the phone. In 2013, biNu was reported to have over 4 million monthly users. Its Worldreader app was released as a beta version in April 2013, which had been installed on about 5 million mobile phones as of 2013-end.[4]

Notes

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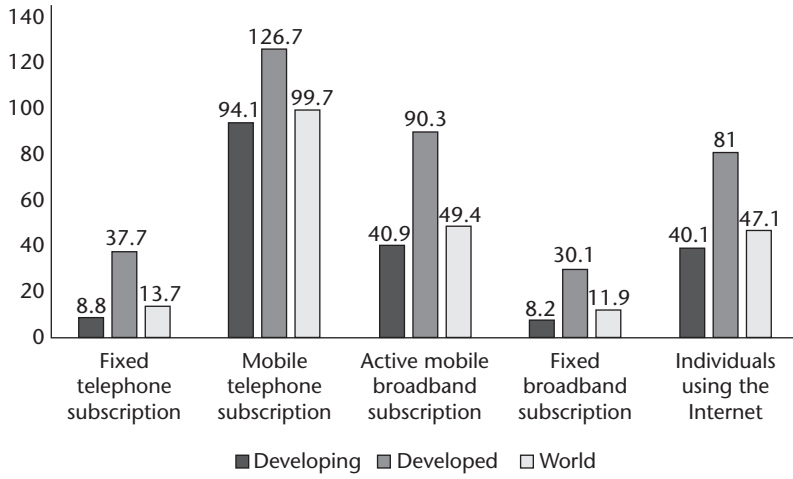

FIGURE 2.1 A Comparison of Subscriptions per 100 People of Different Technologies in Developing and Developed Countries (2016)

Source: ITU, 2016.

applications that are currently accessible only through smartphones. Second, consumers in developing countries are using increasingly sophisticated devices facilitating the diffusion of BD- and cloud-based mobile computing solutions. According to the NPD Group, in the third quarter of 2013, China's smartphone penetration rate was 55 percent. In the fourth quarter of 2013, smartphone sales in India grew by 167 percent.[23] Handset makers, meanwhile, are offering ultra-cheap smartphones. To take an example, China's mobile chip supplier, Spreadtrum Communications and Mozilla, announced that they have teamed up to launch a US$25 smartphone for the world's emerging markets.[24]

The unavailability and high costs of bandwidth can be the major challenges in offering bandwidth intensive applications in developing countries. In countries such as South Africa, whereas bandwidth is available, the price of broadband is a critical barrier for using cloud-based services.[25] Thus most mobile phones used in developing countries are only adequate for non-bandwidth intensive applications such as text messaging.

In order to demonstrate the usefulness, appropriateness, and effectiveness of BD- and cloud-based mobile computing solutions in developing countries, we discuss an application to enhance transparency and fight corruption in Guatemala. In 2010, a national survey of the beneficiaries of Mi Familia Progresa (Mifapro) was administered with low-cost mobile phones and EpiSurveyor (free software) for data collection. Mifapro was the then President Alvaro Colom's flagship social program. It was a conditional cash transfer (CCT) aimed at improving the quality of life of poor families. Before 2010, similar surveys were carried out using paper-based data collection methods, which suffered from

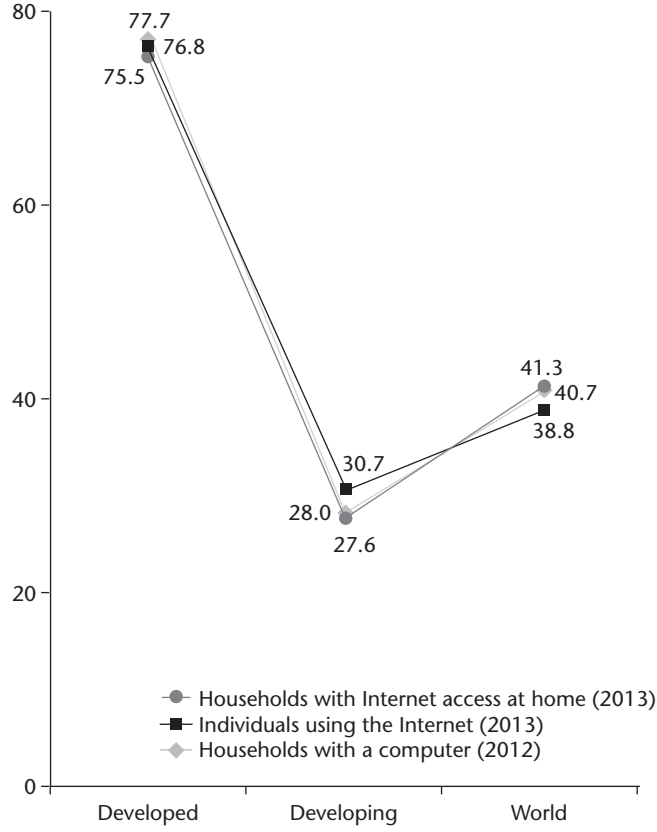

FIGURE 2.2 A Comparison of Computer and Internet Penetrations in Developing and Developed Countries (2012/2013)

Source: ITU, 2014 (computer penetration data are for 2012, Internet penetration data are for 2013).

drawbacks such as frequent errors, storage burdens, and the high costs of double data entry. While handheld devices not connected to the cloud, such as personal digital assistants (PDAs) are sometimes used to replace paper-based methods, they have their own shortcomings. The data need to be downloaded to laptops in frequent intervals are not available in real-time, and may be corrupted or even lost if PDAs are damaged, misplaced, or stolen. In this way, mobile-based clouds perform well from the standpoint of disaster recovery. BD- and cloud-based mobile computing solutions helped overcome these limitations. The 2010 CCT survey relied on EpiSurveyor installed on entry-level mobile phones to collect information from 500 Mifapro beneficiaries, mainly indigenous women. It was funded by the United Nations Foundation, the Vodafone Foundation, and a World Bank Development Marketplace Grant. It drastically reduced the

cost and enhanced survey accuracy. The results accelerated the implementation of a nationally representative beneficiary survey of the CCT program.[26]

EpiSurveyor was arguably the first cloud application for data collection in international development. The process and results were compared with the 2009 paper-based survey conducted with 200 beneficiaries. It was reported that BD- and cloud-based mobile computing solutions reduced average interview cost by 71 percent and average interview length by 3.6 percent. The data quality was reported to improve and 89 percent of the interviewers preferred BD- and cloud-based mobile computing solutions methods compared to the paper-based survey.[27] In contrast to paper- or PDA-based approaches, the use of BD- and cloud-based mobile computing solutions resulted in no data loss.

Other worthwhile applications of BD- and cloud-based mobile computing solutions concern financial services such as stock trading. In October 2010, Intel announced an agreement with an alliance of seventy companies, including the Bombay Stock Exchange (BSE) and CtrlS to develop hardware and software for an open and interoperable cloud. The Open Data Centre Alliance (ODCA) works to address security, energy efficiency, and interoperability.[28] The BSE expects that the new trading platforms supported by BD- and cloud-based mobile computing solutions will broaden the participation of younger Indians, deepen and widen asset classes traded in pension funds, insurance and mutual funds and others.[29] As noted above, as of 2015, only 10 percent of Indians owned a computer, but more than a billion had mobile subscriptions.

2.4 Key Areas of Deployment and Impacts

2.4.1 Impact on the Healthcare System

Some of the most dramatic impacts of BD- and cloud-based mobile computing solutions in developing economies have been documented in health care. For instance, the South African NGO mothers-2-mothers (M2M) system/approach combines the cloud and mobile technologies with a database to fight HIV/AIDS transmission from mothers to children.[30] Note that annually over 400,000 babies are born with HIV infected in Africa. This is partly due to the lack of knowledge about the disease and treatment options as well as the stigma associated with HIV. M2M digitizes patient records and shares with doctors, nurses, mentor mothers, and counselors across its networks of over 700 sites.[31] The records contain information on treatment plans, and advanced reporting tools, which allow quick response. Women in villages authenticate children's medication with text messages.[32] As of 2011, M2M has served more than 1.5 million women in nine SSA countries.[33] It is estimated that the cost is less than US$75 per beneficiary.[34]

Kenya also provides an example of efforts to fight the HIV/AIDS pandemic. It takes three months to get the results of HIV tests in the country. The consequences of the long delay may prove to be fatal as timely treatment

is a key factor for a baby's survival. The Kenyan Ministry of Health has teamed up with several organizations to develop a solution based on mobile clouds in order to reduce the reporting time for HIV test results. A mobile cloud platform enables data gathering on a central server and better structure workflows, delivers test results and produces activity reports on a short notice. It is expected that the implementation of such a platform can reduce the timeline for test result delivery to two weeks.[35]

As a further example, in Malawi, the cloud-based Mother Infant Pair (MIP) mobile application was developed by D-Tree International and designed for Health Surveillance Assistants (HSAs) working with pregnant HIV-infected women. The MIP was developed according to the Community-Based Maternal and Neonatal Care (CBMNC) guidelines, which aims to regulate community infant care until the child is two years old. All HSAs are properly trained on CBMNC guidelines as well as on MIP. During the home visits before and after the birth, the MIP-installed mobile phone takes the HSA over the questions that need to be asked to the client, as well as the associated advice that need to be communicated. MIP uses the General Packet Radio Service (GPRS). Data transmission using the GPRS costs US$0.00003/KB, which is significantly lower than the cost of a SMS, which is US$0.03/KB. The data is sent to a cloud server and can be downloaded from the Internet. The average size of submitted forms is 3–5 KB.[36]

Moving to a different topic, the reduction of maternal and infant mortality is a key priority in many countries. For example, the SDG target is to reduce the global maternal mortality ratio to less than 70 per 100,000 live births by 2030.

As of 2010, about 2,500 midwives were working in 652 primary healthcare centers serving 10.7 million people in Nigeria.[37] BD- and cloud-based mobile computing solutions are well positioned for contributing towards this goal. In order to collect data from midwives, Nigeria's Mobile Application Data Exchange (MADEX) has developed an SMS-based data collection platform. Data sent by midwives is forwarded to the central cloud-based server. Due to simplicity of the processes, cloud-based systems such as MADEX are appropriate for technologically less savvy users.[38] Etisalat Group and D-Tree International teamed up to develop a mobile phone app for African midwives, which can identify risks in pregnant mothers, and find and identify a means of transportation to reach the closest health center.[39] As of 2012, mobile midwife services in Ghana uploaded data from the field, registering health information for 14,000 expectant mothers with a central database hosted in the cloud. The data can be updated by any authorized users such as government workers and local clinicians. The Mobile Alliance for Maternal Action (MAMA) announced that it would reach over 120 million new mothers across Bangladesh, India, and South Africa by 2018.[40]

World leaders have also agreed on a target to end the epidemics of AIDS, malaria, and various other diseases by 2030. The Malaria Surveillance & Mapping project in Botswana was a pilot program launched in 2011, which

aims to move away from paper reports towards mobile clouds. Healthcare workers are equipped with mobile phones to gather and upload malaria data to the cloud. The data can also be tagged with a GPS coordinate, pictures, video, and audio. If there are signals of an outbreak of malaria, Ministry of Health officials and other health workers in the area receive a real-time notification via text message.[41]

In Africa, electronic medical records (EMRs) and electronic health records (EHRs) are being developed and implemented using entry-level cellphones. Before proceeding further, it is important to stress that EMRs such as in the USA would be prohibitively expensive and hard to manage in the developing world. In 2012, Duke University announced its plan to spend US$700 million to implement EHR from the vendor, Epic Systems. EHR projects involve storing additional terabytes of data and providing security capabilities in order to comply with the Health Insurance Portability and Accountability Act (HIPAA) requirements. Maintaining a robust and secure network for doctors and other clinicians to access the data remotely through iPads or smartphones represented additional costs of the project.[42] As another example, California's Sutter Health spent about US$1 billion in EHR.[43] Most developed world-based health organizations suffer from the lack of experienced people to manage high-level projects involving ICTs.[44] Moreover, health organizations need to deal with system breakdown and collapse from time to time. For instance, Sutter Health EHR failed in August 2013. Nurses and clinical staff were unable to access patient information for a day.[45]

In the Millennium Village of Koraro in Northern Ethiopia, community health workers are equipped with cloud-based OpenMRS (medical record system) and a smartphone-based health-data management system. They visit households to collect information and report on diseases such as malaria, number of births, malnutrition incidence, and the health status of pregnant women.[46] At the time, the MVP's goal was to train, equip, and deploy one million community health workers in rural areas of SSA by 2015.[47]

An innovative application in the early phases of development can help to identify counterfeit or sub-standard drugs.[48] Individuals find it difficult to make decisions in the face of inadequate information as to whether a drug they are buying in order to save a life is genuine or not. While buying a drug at a pharmacy store, a customer can find a twelve-digit code by scratching a sticker on the surface of the package and then send a text message to a given number. The code sent by the customer is matched with the one registered by the pharmaceutical company in HP's cloud database. The customer then receives a response back that tells whether the drug is counterfeit or genuine. Although this application provides obvious commercial benefits to drug manufacturers and patients, one of the most important ones is that it helps save lives by enabling the customers to check the authenticity of life-saving drugs. This system was developed in Africa by the non-profit organization, mPedigree, and HP Labs. The techno-

logy provider had launched a program to track and authenticate drugs in Nigeria and Ghana. As of September 2011, HP was negotiating with Indian pharmaceutical companies such as Cipla, Tablet India, and CAMA.

In Africa, Bharti Airtel and the US company Sproxil have teamed up to crack down on counterfeit pharmaceuticals using similar technology—Sproxil's Mobile Product Authentication (MPA) system. As of 2012, Sproxil operated in Ghana, Kenya, Nigeria, and India. According to the World Health Organization, counterfeit medicines can account for 30 percent of the market in many African countries.[49] One study conducted in twenty-one SSA countries found that one-third of malaria drug samples failed chemical testing and one-fifth were confirmed as fake.[50]

Drug manufacturers have realized that taking counterfeits off the market and making counterfeiters unprofitable is only one of the many benefits that Sproxil's MPA system can offer. Drug manufacturers can also get insights into locations that are counterfeit hotspots and the quantities of counterfeit drugs.

BD- and cloud-based mobile computing solutions are also contributing to the growth of health micro-insurance programs. Linda Jamii (Swahili for "protect your family"), is a mobile cloud-based health micro-insurance program implemented by Safaricom in partnership with Changamka Micro-Health and the insurance provider Britam. Linda Jamii's clients are self-employed Kenyans. It provides in-patient and out-patient cover, maternity cover, dental and vision, income replacement, funeral expense payout, and other coverage for an annual premium of US$150 per family. While registration for insurance must be done in person, the rest of the processes, such as registration and submitting claims, are done through a mobile phone. A cloud-based application manages the entire process.[51]

2.4.2 Impact on the Farming and Agricultural Sector

Total factor productivity in agriculture is much lower in LDCs than in developed economies.[52] World leaders have set as a target under the SDGs to double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists, and fishers. Technology can again serve an important role in this context.

Most encouraging and inspiring examples of mobile-based cloud computing deployments can be found in SSA, which have led to economic and social transformations. For instance, uses of mobile clouds in agricultural and farming activities have markedly enhanced productivity. For instance, the Apps4Africa Award-winning app iCow, already mentioned, helps small-scale dairy farmers track and manage their cows' fertility cycles. The app informs farmers about the important days of cow gestation period; collects and stores milk and breeding records, and sends farmers best practices. It also helps farmers find the nearest vets and other service providers. Its developer, Green Dreams, has also formed a

system involving Google Docs. If Green Dreams and the vet contacted by the farmer are unable to answer the farmer's question, it is uploaded on the system. The vets send messages among themselves and come up with the best answer, which is then forwarded to the farmer.[53] As of December 2012, different features of the iCow platform were used by 42,000 farmers in forty-two countries. Due to the ease of use, affordability, and convenience, iCow has high retention and satisfaction rates. For instance, iCow's surveys indicated that 82 percent of farmers who started using the platform in June 2011 were still using it until January 2012.[54] In June 2013, Safaricom announced a partnership with iCow.[55]

In Uganda, so-called "community knowledge workers" (CKWs) use Android phones loaded with an open-source data collection application. Data is automatically fed into the clouds of the US cloud provider Salesforce. As of 2011, there were about 400 CKWs in Uganda. They used solar power, bicycles, and other means to recharge the phone batteries. The concept was developed by the Seattle-based Grameen Foundation Technology Center. It offers selected farmers loans to buy an Android phone, which is loaded with information about the time and methods of planting crops, caring for farm animals, and finding markets for products. Those farmers act as CKWs and serve as experts in the villages. Other farmers can ask questions about crops or farm animals. The CKWs interact with farmers and gather information about them.[56]

The project also created a cloud-hosted database for Ugandan farmers. Farmers contribute questions and answers about agricultural practices for the database. It contains answers to frequently asked questions, which can be accessed via a free SMS service. The project generated US$1 million in income when government agencies and commercial organizations in Uganda paid for farming data. For instance, a brewery in the capital city Kampala wanted information on barley crop supply chains.[57]

Another innovative BD- and cloud-based mobile computing solution is Farmforce, a US$2 million platform developed by the Swiss-based Syngenta Foundation for Sustainable Agriculture, which was backed by the Swiss government. Small-scale farmers in Kenya use the cloud-based mobile platform Farmforce software to store and manage data on pesticide contents in their crops before exporting. Farmforce operates on a subscription-based SaaS model, which tracks pesticide residues in produce. Farmers can access the software freely online via a mobile phone. The farmers no longer need to use manual record keeping of farm activities and operations.[58] Farmforce software can be used for all types of crops. It was reported that a number of developing countries such as Ghana, Guatemala, Indonesia, Nigeria, and Zimbabwe had expressed interest in Farmforce.[59] Despite the rising demands in industrialized countries of fruit and vegetables, developing-world-based small-scale farmers face barriers related to quality standards and pesticide traceability.[60] The use of Farmforce would help small-scale farmers identify and document important

requirements related to quality standards and pesticide traceability in order to improve marketability of their crops.

The Nigerian farm services company Babban Gona (which means "Great Farm" in Hausa) has been using Farmforce since 2013. In the first year, 692 farmers were enrolled, which covered 583 hectares.[61] The number of farmers enrolled increased to more than 2,000 in 2014.[62] Farmforce records information about farmers' personal profiles, growing activity, yields, and other indicators.

As yet another example, in Uganda, cloud-based mobile platforms have helped small farmers access agricultural information and financial services. For instance, farmers can use mobile phones to order and pay for seeds and fertilizers, and collect payment for their produce.[63]

The cloud-based platform, AgriLife, which is accessible via mobile phone, is used for collecting data and analyzing farmers' production capability and history. In order to ensure fast, easy, and efficient availability of resources and services to distant, rural farmers, the platform also acts as an integration point for financial institutions, mobile network operators, produce buyers, and their agents.[64] The data analysis provides a better understanding of small farmers' needs and production capability. Service providers can tailor their offerings such as crop insurance, input payments, and savings accounts based on the data.[65] Uganda's Farmers Centre (FACE) was an early adopter of AgriLife. FACE started uploading information on its 10,000 farmer clients, who travel long distances to purchase inputs and aggregate their produce at FACE warehouses for processing/sale. Before using AgriLife, FACE collected information by paper-based questionnaires. The data was stored on a computer, which had crashed. A cloud-based farmer registration process via mobile phone thus proved to be an attractive option. Small farmers' transaction data helps them build a credit history, which is used by value-chain actors to provide credit and other resources such as seeds, fertilizers, and pest-control chemicals agents.[66]

The AgriLife platform was developed by the Kenya-based IT company MobiPay and was launched in late 2012. Mercy Corps supported the expansion of AgriLife to Uganda and helped build relationships with other service providers and integrate them into the platform so they can reach rural clients more effectively. As noted earlier, as of September 2013, AgriLife has facilitated over US$2 million in revolving credit lines to about 120,000 small farmers in Kenya and Uganda. The AgriLife platform is also being used in Zimbabwe, Zambia, and Senegal.[67]

2.4.3 BD- and Cloud-Based Mobile Computing Solutions in the Development of Index Insurance

Several researchers and practitioners have advocated the development and use of index insurance contracts to manage the risks faced by farmers and agricultural producers.[68] Note that whereas conventional insurance compensates an insurer

based on verifiable losses, under an index insurance scheme, payment to an insured farmer depends on the observed value of a specified "index."[69] Prior researchers have suggested that the benefits of index insurance contracts are likely to be greater to lending institutions such as agricultural and industrial development banks and MFIs than to an individual borrower.[70] The development of an index that would provide an accurate measurement of systemic agricultural production shocks in a lending institution's geographic boundaries can help effectively track its cash flows.[71] This means that by diversifying a large proportion of the borrower-specific idiosyncratic risks, a lending institution is likely to face lower basis risk than faced by its borrowers individually.[72] The loan portfolios of most MFIs in developing countries are typically concentrated in urban areas. Systemic risks associated with droughts, floods, cyclones, and other extreme weather-related events tend to make agricultural loans less attractive and hinder the ability and enthusiasm of MFIs to expand their services to rural farmers.[73]

The social enterprise Kilimo Salama (which means "safe agriculture" in Swahili) developed an index insurance in an attempt to serve a vulnerable market that traditional insurance schemes do not reach. Kilimo Salama was a partnership between the Syngenta Foundation for Sustainable Agriculture, UAP Insurance, and Safaricom. It developed a scheme for small farmers in Kenya to protect them against poor weather conditions. Its "weather-based index insurance" uses weather stations across the country. Farmers can buy the insurance at the beginning of the season for about 10–20 percent of the amount they invest in seeds and inputs.[74] For some farmers the cost of insurance amounts to as little as 1 kg of maize, seed, or fertilizer.[75] The insurance, which is completely automated, is distributed through dealers who use an advanced phone application with camera and phone functions to scan and capture policy information through a code. The information is uploaded to Safaricom's mobile cloud-based server, which administers policies. Farmers receive information about their policy and payouts in SMS messages.[76] Weather stations are equipped with wireless sim-cards that transmit data every five minutes to a cloud-based server. At the end of the season, the data is aggregated and coupled with satellite data, and used to map out rain patterns. Kilimo Salama then worked with agronomists to calculate the index to identify the locations with too much rain, too little rain, or rain at the wrong time. Farmer payouts are calculated based on their crops, location, and the number of seeds purchased.[77] Thanks to Kilimo Salama's insurance scheme, banks and micro-finance institutions were more comfortable in giving loans, making access to essential credit easier for farmers.

The for-profit company, Acre Africa, evolved from the Kilimo Salama project and is now the brand name of Agriculture and Climate Risk Enterprise Ltd (ACRE). It continues to link farmers to insurance products so that they can confidently invest in their farms. Cumulatively, by 2015, over 800,000 farmers in Kenya, Tanzania, and Rwanda had been insured through products designed by the company.[78]

2.4.4 Impact on Educational Outcomes

BD- and cloud-based mobile computing solutions can also have a positive impact on education and literacy-related activities. The Connect to Learn (CtL) program provides schools with laptops or netbooks and free wireless to access news, information, and educational content in the cloud.[79] The students can also interact with fellow students around the world.[80] As of early 2014, there were twelve CtL program sites in ten countries in Africa.[81]

Philanthropic and charitable causes have also been a factor in stimulating the deployment of BD- and cloud-based mobile computing solutions in such activities. For instance, Worldreader, which describes its mission as to "make digital books available to children and their families in the developing world, so millions of people can improve their lives," uses [Amazon's] AWS to download books.[82] Worldreader has made thousands of free books available on the cloud which can be accessed by low-end mobile devices and older 2G mobile networks. The books can be accessed through a free mobile software platform biNu. Most of the processing is performed in the cloud's servers instead of on the phone, which allows biNu to work ten times faster than regular mobile web browsers.[83]

As noted above, the education and literacy charity Worldreader launched a book app, with thousands of free books, which consists of a wide range of genres such as romance novels to mathematics textbooks. The app is designed to run on moderately priced and multipurpose phones (feature phones)[84] rather than high-end smartphones. In this way, biNu allows feature phones and low-end smartphones to have a smartphone-like experience through cloud-based apps and services.[85] This also means that the app is appropriate for SSA's overcrowded narrow band 2G networks, which are primarily used for voice transmission but are also capable of transferring data, but only very slowly and unreliably. Note too that 2G networks are less compatible with the functions of smart phones. The app can be accessed through biNu, which is a free software delivery platform for mobile devices. biNu *also* gives users free airtime on prepaid mobile phones for completing surveys.[86]

2.4.5 Impacts on Business Processes, Productivity, and the Creation of Markets

In this section, we discuss the impacts of BD- and cloud-based mobile computing solutions on business processes and productivity and the creation of markets. BD- and cloud-based mobile computing solutions allow for better workflow by saving time and allowing data to flow automatically into the clouds. The impacts on business processes and productivity were illustrated above through various examples and comparisons with other available alternatives (Table 2.3).

TABLE 2.3 Some Examples of the Impacts of Big Data- and Cloud-Based Mobile Computing Solutions on Improving Business Processes and Productivity and Creation of Markets

	Improving Business Processes and Productivity	*Creation of Market*	
		Facilitating Information Exchange	*Matching Buyers and Sellers*
Healthcare	• M2M digitization of patient records have led to lower costs and quicker response. • The Kenyan Ministry of Health's proposed BD- and cloud-based mobile computing solutions solution is expected to reduce the timeline for HIV test result delivery from three months to 2 weeks.	• M2M's sharing of patient information with counselors. • The HP's cloud database was designed to provide information as to whether or not a drug is genuine.	• Mobile phone app for African midwives developed by Etisalat. Group and D-Tree find and identify a means of transportation to reach the closest health center.
Primary economic ctivities such as agriculture and livestock-raising	• FACE's use of AgriLife to collect information about farmer clients led to lower data collection costs compared to paper-based questionnaires. • Farmforce eliminated the need to use manual record keeping of farm activities and operations. • iCow's positive impact on milk production.	• Kilimo Salama's weather-based index provides information for banks and MFIs, to provide loans to farmers. • AgriLife: Service providers can tailor offerings such as crop insurance, input payments, and savings accounts based on small farmers' needs and production capability. • Esoko collects and provides information on current market prices.	• iCow helps farmers find the nearest vets and other service providers. • Esoko provides information on bids and offers.
SMEs in non-primary economic activities	• The MTN Cloud offers packages to manage the infrastructure and platforms to support business functions such as accounting, human resource, customer relations management, email and videoconferencing, storage and back-up for small businesses.	• Kopo Kopo allows SMEs to employ SMS to communicate with customers.	• Lula owners act as intermediaries, matching buyers with sellers of airtime.

Let us now consider such possibilities in small- and medium-sized enterprises (SMEs). The South Africa-based telecommunications company MTN launched pilot cloud computing services targeting SMEs in Uganda, Cameroon, Côte d'Ivoire, Ghana, Nigeria, and South Africa. Following the pilot projects, it launched a suite of cloud services for SMEs in Ghana and Nigeria in December 2012. For instance, MTN MyOffice, a suite of SME-focused ICT solutions designed to enhance the way businesses work and collaborate is available in Nigeria.[87] The subscribers of MTN's SME Closed User Group (CUG) can pay a flat monthly fee and enjoy zero-rated call services among their staff. The service is available to SMEs with 2–199 employees. According to MTN, this offering has already been adopted by SMEs in manufacturing, hospitality, micro-finance, and advertising. The MTN Cloud offers packages to manage the infrastructure and platforms to support business functions such as accounting, human resource, customer relations management, email, and video conferencing, storage and back-up for small businesses. The business software and data are stored on a cloud which end-users can access through mobile phones as well as a PC.[88]

The roles of BD- and cloud-based mobile computing solutions in market creation are much less appreciated but may be quite important. Kenya's Musoni Systems established the world's 100 percent mobile micro-finance institution in 2009.[89] Its cloud-based core banking solution has a huge amount of information on small-scale financial service providers as well as low-income consumers.[90]

Among the key functions of markets are to match buyers and sellers, facilitate the exchange of information, goods, services, and payments and to provide an institutional infrastructure, such as a legal and regulatory framework.[91] Factors such as transportation and communication infrastructures and intermediary institutions are essential for the creation and functioning of markets.[92] Regarding buyer/seller matching services, more broadly, we discuss how BD- and cloud-based mobile computing solutions have facilitated the dialogue, interaction, and coordination between producers and users of goods and services in developing countries. Market creation can occur through various mechanisms and with varying effects on the market participants. The HP's cloud database was designed to provide information as to whether or not a drug is genuine. Lula owners act as intermediaries, matching buyers with sellers of airtime.

Developing world-based farmers are often paid low prices for their products. On the other hand, the poorly informed farmers pay higher prices in order to obtain the needed inputs that market conditions dictate.[93] BD- and cloud-based mobile computing solutions have made it possible to fight these problems. In Mauritius and Ghana, Esoko, a mobile-enabled cloud service, collects and provides information to farmers on such topics as current market prices, bids and offers, weather, and tips. Advisories are also sent by voice messages and a live call center of agricultural experts is made available.[94]

SMEs are especially likely to benefit from the data and information created by BD- and cloud-based mobile computing solutions because developing economies are characterized by the lack, or poor performance, of credit rating agencies providing information about the creditworthiness of SMEs. A national credit bureau would collect and distribute reliable credit information and hence increase transparency and minimize the banks' lending risks. Many emerging economies lack such an agency and some have a poorly functioning one. This situation puts SMEs in a disadvantaged position in the credit market. SMEs tend to be more informationally opaque than large corporations because they often lack certified audited financial statements and thus it is difficult for banks to assess or monitor their financial conditions.[95]

2.5 Discussion and Concluding Comments

Developing economies' broad political, economic, and social contexts have given rise to the growth of BD- and cloud-based mobile computing solutions. Unsurprisingly, a number of creative approaches to the deployment, operation, and use of BD- and cloud-based mobile computing solutions have already been reported in the developing world. While initial investment costs may be relatively high in some cases, possible savings due to efficiency gains, improved quality, and other advantages are obtained, which often exceed the initial investment. The simple fact that the data are created digitally as opposed to being digitized manually dramatically reduces the costs. The cost savings that could be achieved through the immediate digitization and data transmission and automated data aggregation were much greater than the purchasing and data transmission costs of mobile phones.[96]

One advantage of the cloud is that if a device fails or is lost, the information is still securely saved in the cloud.[97] There is no need to worry about data loss in issues such as theft and burglary involving cellphones and computer crash, which are not uncommon. To take just one example, between 2010 and 2011, three million cellphones were stolen in Colombia.[98] Likewise, before using AgriLife, FACE had collected information on its clients (farmers) and stored on a computer, which had crashed.[99]

We noted earlier that health organizations in the USA suffer from the lack of skills related to high-level project management.[100] The shortage of skills and talent is a more serious problem in developing countries. Since clients can access resources from a web browser, they are not required to install or download anything on their devices. The cloud is thus a more appropriate choice.

Kopo Kopo's software and Nomanini's Lula capitalize on, adapt to, and improve the functioning of the mobile money market. For instance, Lula owners wear a lanyard around their necks to carry the device so they are instantly noticed in places such as a busy train stations.[101] Africa's prepaid airtime market was estimated at US$60 billion in 2013.[102] A key reason behind the

increasing success and popularity of Lula is that prepaid minutes can be used as cash or spent in shops in a number of African countries such as Côte d'Ivoire, Egypt, Ghana, Uganda, and Nigeria.[103] In November 2013, Nomanini entered the Kenyan market. The company also announced its plan to enter Zambia, Nigeria, and Tanzania.[104] Many people in Africa, especially in rural areas, use such vouchers to pay for services such as electricity, water, insurance, and airtime for mobile phones. The low penetration rates of computers, the Internet, and smartphones, and the fact that a large proportion of the population lacks a documented home address make this an attractive option economically and technologically. Mobile prepaid services do not require Internet access or a bank account and can be purchased in small or large amounts. A further reason for the popularity of such vouchers is that it is difficult to distribute physical vouchers because of theft and fraud risks.

The lack of availability and quality of cloud-related infrastructure have hindered cloud adoption in developing countries.[105] In SSA, only 53 percent of the urban population and 8 percent of rural population have electricity. According to PenWell Corporation, the SSA generates 47 MW of electricity, which is less than 0.6 percent of the global market.[106] Likewise, according to the consultancy firm Balancing Act, SSA had less than 100 data centers in 2011.[107] In the same year, there were more than 500,000 data centers worldwide,[108] which means that SSA accounted for less than 0.02 percent of the data centers worldwide. There is also the lack of high bandwidth infrastructures. As of 2012, eight SSA countries were 100 percent dependent on satellite for international connectivity due to the lack of fiber optic links.[109] Moreover, the battle to provide cloud services is about more than just getting fiber connections. For instance, in the early 2013, Liberia and Sierra Leone were connected to the ACE cable, which was their first fiber network. Since only a few landlines exist in these countries, dispersing bandwidth would take further efforts.

Economic and infrastructure-related barriers, while less pronounced, remain significant for many people living in a rural area, and poor households. In Uganda, low network coverage and the instability of the network in the most remote areas have acted as major barriers that have hindered or slowed down the wide acceptance of mobile clouds. Additional barriers that revolve around the lower adoption of the technology include the high cost of phones (about US$20) and calls (about US$0.20 per minute), and the difficulty in charging mobile phones.[110]

Developing countries perform relatively poorly compared to developed countries in most factors related to cloud computing. On the other hand, some constraints that have hindered the diffusion of the cloud in developed countries are less restrictive in developing ones. For instance, due to the requirement of stringent security measures in order to comply with the HIPAA requirements, healthcare organizations in the USA are reluctant to use the cloud despite significant potential efficiency gain.

The Mifapro case shows how data collection using the cloud and mobile technologies can help coordinate, monitor, evaluate, and implement policies that are targeted towards the poor indigenous and disadvantaged groups living in remote, marginalized, and underdeveloped areas. The deployment of the cloud in rural areas may also create significant business opportunities.

Notes

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3

PRIVACY AND SECURITY ISSUES ASSOCIATED WITH BD AND THE CLOUD

3.1 Introduction

Privacy and security issues associated with BD and the cloud have been a top concern for firms in developing as well as developed countries. According to a study conducted by EMC in 2014, data loss and associated business downtime cost the global economy over US$1.7 trillion annually.[1] China alone is estimated to have more than 1.5 million hackers, who have created an underground industry of more than US$15 billion by exploiting security flaws in BD, the cloud, and the IoT.[2] Likewise, a study conducted by Compfix Data indicated that over 45 terabytes of data is lost every year in Kenya alone. The study also found that a company that experiences an outage of ten days or more due to data loss cannot fully recover and 50 percent of such companies go bankrupt.[3]

Likewise, GCC economies' modernization of their natural gas and petrochemical industries involves significant investment in BD and the cloud, making CS a key security concern. The attacks on Aramco, which were attributed to a virus called Shamoon, wiped out the hard drives of 30,000 computers, 85 percent of the oil giant's devices, shutting the company's business down for two weeks, which cost the company over US$15 million.[4] Several months later, the Shamoon malware attacked again in an attempt to disrupt international supply flows.[5] This problem extends past Saudi Arabia: in the same month, Qatar's liquid natural gas company RasGas experienced cyber-attacks associated with the same virus, shutting down their website and computer servers.[6]

According to the 2016 Vormetric Data Threat Report (DTR) released by Vormetric, a CS company, 87 percent of Mexican and 84 percent of Brazilian IT decision makers thought that their organizations were vulnerable to cyber-attacks.[7] The survey also found that 65 percent of organizations in Mexico and

62 percent in Brazil had experienced a CS breach in the past. Such concerns have acted as a primary barrier to the adoption of BD and the cloud. Due to concerns related to data security and overall benefits, businesses are cautious in spending in BD and cloud services.[8] For instance, according to a survey released by Microsoft in 2014, 32 percent of South African businesses and 33 percent of Egyptian businesses expressed concerns about cloud security. The proportion for the MEA (Middle East and Africa) was 26 percent.[9]

BD and cloud security issues are related to a number of important organizational outcomes. For instance, cloud services in some countries are experiencing a negative country-of-origin effect due to security issues. For instance, according to the 15th annual Business Climate Survey of the American Chamber of Commerce in China conducted with companies operating in China (most of which were from the USA) ("AmCham China"), which was released in March 2013, only 10 percent considered using China-based cloud computing. The respondents expressed concerns about data security. Twenty-six percent of the respondents stated that their proprietary data or trade secrets related to China operations had been stolen.[10]

A top concern for consumers has been privacy and security practices of companies handling their data. For instance, online credit services in China that use BD analytics in extending loans are being accused of abusing personal data to collect debts. Alibaba's Ant Check Later, which allows users to delay payments and pay in installments, allegedly misused personal data. An online user reported that he was contacted by Ant Check Later for information about his friend, who owes money to the payment service. Users of JD.com (Jingdong Mall) reported similar problems. JD.com financial unit operates JD Baitiao, which is similar to Ant Check Later. In a question posted on the online legal advice site 110.com, a JD.com user asked if it was legal for JD.com to give a third-party service his personal information for the purpose of debt collection. Ant Financial Services reportedly said that the practice of contacting a borrower's friends or relatives to help with collecting debts is common in the financial sector. *TMTpost* cited a *China Youth Daily* poll, which showed that 75.9 percent of respondents believed there was abuse of BD.[11]

Finally, it is important to compare privacy and security issues associated with BD and the cloud in developing and industrialized countries. In the industrialized world, cloud and BD users are becoming educated and are bringing more holistic perspectives to incorporate all the relevant issues that are important to them such as cost saving, productivity gain, security and privacy issues and, control over data. They have also changed their behavior in response to changing perceptions of the benefits and risks and their potential and realized power. Over time, this may give venders a better assessment of clients' needs and power, which may lead to an effective tailoring of services and improvements in privacy and security issues.[12] Such conditions are less likely to be found in developing countries due primarily to the newness of the cloud and BD.

3.2 Characteristics of Big Data and the Cloud in Relation to Security and Privacy

3.2.1 Security and Privacy Issues Associated with the Cloud

A significant gap remains between CSPs' claims and users' views of the cloud's security, privacy, and transparency. The cloud industry's response has been: "Clouds are more secure than whatever you're using now."[13] But many users do not agree. Issues such as security, privacy, and availability are among the topmost concerns in organizations' cloud adoption decisions rather than the total cost of ownership.[14] Due primarily to concerns related to security, privacy, and confidentiality, critics have argued that its perceived costs may outweigh the benefits.[15] Organizations worry about hidden costs associated with security breaches or lawsuits tied to data breach. Many businesses and consumers are cautious in using the clouds to store high-value or sensitive data and information.

3.2.2 Security and Privacy Issues Associated with Big Data

As presented in Table 3.1, the various characteristics or dimensions of BD identified by Gartner and SAS are tightly linked to privacy and security issues. For instance, in order to create highly customized offerings, a company may need to mine a huge amount (volume) of structured and unstructured (variety) data from multiple sources (complexity). In some cases, this process may also involve the use of high velocity data. BD may challenge the Fair Information Practices (FIPs), which are an established set of principles for addressing privacy concerns on which modern privacy laws are based (Table 3.1).[16]

Finally, if consumer data is not handled appropriately by organizations, in addition to privacy and CS issues, there are also possibilities of civil rights violation such as discrimination. For this reason, regulators such as the Federal Trade Commission (FTC) are showing concerns that BD may "perpetuate and even amplify" societal biases by screening out certain groups, often disadvantaged ones, from opportunities for employment, credit, or other forms of advancement.[17]

3.2.2.1 Volume

Developing world-based organizations are experiencing a huge amount of data flows from various sources. For instance, Etisalat's operating brand, Mobily, in Saudi Arabia noted that 1.3 petabytes of data flows daily through the company's network.[18] Organizations such as Etisalat are often required to store all data in one location in order to facilitate analysis. The higher volume and concentration of data makes a more appealing target for hackers. Moreover, a higher data

TABLE 3.1 Big Data Characteristics in Relation to Security and Privacy

Characteristic	*Explanation*	*Effect on Privacy and Security*
Volume	Huge amount of data is created from a wide range of sources such as transactions, unstructured streaming from text, images, audio, voice, VoIP, video, TV and other media, sensor and machine-to-machine apps.	• High data volume would likely attract a great deal of attention from cybercriminals. • Amplified technical impact. • Violation of transparency principle of FIPs. • Firms may need to outsource to CSPs which may give rise to privacy and security issues.
Velocity (Fast Data)	Some data is time-sensitive for which speed is more important than volume. Data needs to be stored, processed and analyzed quickly.	• Increasing consumer concerns over privacy in the context of behavioral advertising based on real-time profiling and tracking technologies such as cookies. • Violation of the individual participation principle of FIPs. • Increase in the supply and demand of location-based real-time personal information, which has negative spillover effects (e.g., stalking people in real-time). • Physical security risks.
Variety	Data comes in multiple formats such as structured, numeric data in traditional database and unstructured text documents, email, video, audio, financial transactions.	• Unstructured data is more likely to conceal PII. • A large variety of information would make it more difficult to detect security breaches, react appropriately and respond to attacks (freepatentsonline.com, 2003). • Most organizations lack mechanisms to ensure that employees and third-parties have appropriate access to unstructured data and they are in compliance with data protection regulations.
Variability	Data flows can vary greatly with periodic peaks and troughs. These are related to social media trends, daily, seasonal and event-triggered peak data loads and other factors.	• Organizations may lack capabilities to securely store huge amounts of data and manage the collected data during peak data traffic. • Attractiveness as a crime target increases during peak data traffic. • Peak data traffic may cause higher needs to outsource to CSPs which give rise to important privacy and security issues.
Complexity	Data comes from multiple sources which require linking, matching, cleansing, and transforming across systems.	• Resulting data is often more personal than the set of data the person would consent to give. • Data collected from illicit sources is more likely to have information on technologically less savvy consumers, who are likely to suffer a more negative welfare effect than technologically more savvy consumers.

Source: Adapted from N. Kshetri, Big Data's Impact on Privacy, Security and Consumer Welfare, *Telecommunications Policy* (2014) 38, 1134–1145.

volume increases the probability that the data files and documents may contain inherently valuable and sensitive information. Information stored for the purpose of BD analytics is thus a potential goldmine for cybercriminals. A huge amount of data means that security breaches and privacy violations are likely to lead to more severe consequences and losses via reputational damage, legal liability, ethical harms, and other issues, which is also referred to as an amplified technical impact.[19]

The availability of a huge amount of data also increases the possibility that personal data can be put to new uses to create value. The US FTC Commissioner pointed out the possibility that firms, "without our knowledge or consent, can amass large amounts of private information about people to use for purposes we don't expect or understand."[20] Such uses often violate the transparency principle of FIPs.[21]

A huge data volume is also related to the demand or even the necessity of outsourcing. An issue of more pressing concern is determining relevance within large data volumes and how to use analytics to create value from relevant data. Firms may thus rely on CSPs for analytic solutions.

3.2.2.2 Velocity

The quickly degrading quality of real-time data is noteworthy.[22] In particular, clickstream data (clickpaths), which constitute the route chosen by visitors when they click/navigate through a site, is typically collected by online advertisers, retailers, and ISPs. The fact that such data can be collected, stored, and reused indefinitely poses significant privacy risks.[23] Some tracking tools can manipulate clickstreams to build a detailed database of personal profiles in order to target Internet advertising.[24]

An important use of BD is real-time consumer profile-driven campaigns such as serving customized ads. For instance, location-tracking technologies allow marketers to serve SMS and other forms of ads based on real-time location. This process often involves passive data collection without any overt consumer interaction. The lack of individual consent for the collection, use, and dissemination of such information means that such a practice violates the individual participation principle of FIPs.[25]

BD initiatives have led to an increase in both the supply and demand of location-based real-time personal information. Data created and made available for use in the implementation of BD initiatives also have negative spillover effects. Particularly, the availability of location information to third parties may have some dangerous aspects. One example is the use of location data for stalking people in real-time. For instance, the iOS app *Girls Around Me*,[26] which was developed by the Russian company I-Free, leveraged data from Foursquare to scan and detect women checking into a user's neighborhood. The user could identify a woman he liked to talk, connect with her through Facebook, see her

full name, profile photos, and also send her a message. The woman being tracked however would have no idea that someone was "snooping" on her.[27] As of March 2012, the app had been downloaded over 70,000 times.[28]

There is also a physical risk of (near) real-time data. For instance, a *China Daily* article commented that in China, illegal companies buy databases from malicious actors and provide services to their clients, which include private investigation, illegal debt collection, asset investigation, and even kidnapping.[29]

3.2.2.3 Variety

By combining structured and unstructured data from multiple sources, firms can uncover hidden connections between seemingly unrelated pieces of data. In addition to the amount, a high variety of information in BD makes it more difficult to detect security breaches, react appropriately, and respond to attacks.[30]

One estimate suggested that only about 10 percent of available data is in a structured form (e.g., transactional data on customers, time-series data from statistical agencies on various macro-economic and financial indicators) which can be presented in rows and columns.[31] Especially because of the relative newness, most organizations lack the capability to manage unstructured data, which arguably contains more sensitive information. Processes and technology solutions for securing unstructured data are still in the nascent phase and governance issues are not addressed.[32] For instance, organizations often lack mechanisms to ensure that permanent and temporary employees and third parties have appropriate access to unstructured data and that they are in compliance with data protection regulations.[33] According to a survey released in 2013 by Ernst & Young Global Limited, which was conducted among Indian firms, 43 percent of the respondents were concerned about data privacy and the security risks associated with handling of unstructured data as among the major challenges.[34]

3.2.2.4 Variability

The variability characteristic is related to the time-variant nature of security and privacy risks. The volume of data collected and stored, which need protection, will grow during the peak data collection and flow periods. It is during such periods that organizations may lack the internal capacity and tools to manage and protect information. A related point is that the attractiveness as a crime target is high during such periods.

The variability characteristic of BD may also necessitate the outsourcing of hardware, software, and business-critical applications to CSPs. Applications such as ERP and accounting systems are required to be configured for peak loads during daily and seasonal business periods or when quarterly and annual financial statements are prepared.

3.2.2.5 Complexity

BD often constitutes aggregated data from various sources that are not necessarily identifiable. There is thus no process to request the consent of a person for the resulting data, which is often more personal than the set of data the person would consent to give.[35] A related privacy risk involves re-identification. It is possible to use a data aggregation process to convert semi-anonymous or certain personally non-identifiable information into non-anonymous or personally identifiable information.[36] Health-related data is of special concern. Based on a consumer's search terms for disease symptoms, online purchases of medical supplies, and RFID tagging of drug packages can provide marketers with information about the consumer's health.[37] Access to such information would enable an insurance underwriter to predict certain disease and disorder probabilities, which would not be possible using information voluntarily disclosed by consumers.

Many of the innovations involving BD use multiple data sources and involve transferring data to third parties.[38] Many organizations believe that making data anonymous before sharing with third parties would make it impossible to identify. This is often a convenient but possibly false assumption. Researchers have presented a variety of methods and techniques that can be used to de-identify personal data and reassociate with specific consumers.[39] BD processes *can* generate predictive models that have a high probability of revealing PII[40] and thus make anonymization impossible. Failure to protect PII and unintended or inappropriate disclosure violate the security provision of FIPs.[41] In some cases, the identified person may suffer physical, psychological, or economic harm.

Some data may come from illicit sources. One example is the criminal outfit, Superzonda, which allegedly sent 30–40 million spam emails a day in the early 2000s.[42] Superzonda's most profitable venture was to provide information on consumers interested in a product (e.g., mortgage) to legitimate businesses for lead generation. Each package of data (consisting of name, phone number, address, amount of loan desired and current home value) was reportedly sold to mortgage companies for US$20.[43] Less sophisticated and vulnerable consumers are more likely to be fooled by the tricks of illicit actors such as Superzonda.

3.3 The Security and Privacy Situation in Developing Countries in the Context of BD and the Cloud

Most of the current discussion on BD and the cloud in relation to security and privacy has been focused on industrialized countries. One commentator noted that about 90 percent of the discussion at the 2013 Internet Governance Forum (IGF) held in Bali, Indonesia referred to BD as a surveillance tool. At the same time, the debate focusing on developing countries treated BD as a means to

observe people to fight poverty. The argument provided by IGF participants was that data can help provide access to clean drinking water, health care, and other necessities. Some have challenged this view and noted that poor people have no less reason than rich people to be worried about surveillance.[44]

Privacy violation is most likely to occur in countries with poor protection of civil liberties. The worst case is that authoritarian governments may see and use detailed, real-time data on citizens. However, due to the secrecy in the way information is handled, the affected individuals may not have a way to know that their information is inappropriately accessed and used. Likewise, some businesses may obtain, use, and sell personal data for their own gain. There may not be any restrictions on such activities and people whose information is used or sold may lack control over how their personal data is handled.[45]

CS and privacy issues in developing countries need to be seen in the backdrop of rapid diffusion of modern technologies such as the IoT. Banks and retailers are using customers' real-time geo-location technologies for authentication and other purposes. New types of biometric data such as fingerprints, iris scans, voice-recognition software, and facial recognition are also being used for authentication. Location and financial data and other information can be attacked by cybercriminals. Such new developments require new security measures and user authentication to make sure that customers are happy and transmitted data is secure. It is important for users to understand that they can fully trust the connected devices that are tied to bank accounts.[46]

Most developing world-based organizations which collect consumer data perform extremely poorly in protecting privacy. Consider the 2015 Corporate Accountability Index of the Washington DC-based non-profit research initiative, Ranking Digital Rights.[47] With regard to user privacy, Tencent ranked thirteen out of the sixteen tech companies surveyed. The survey did not include Baidu and Alibaba. The companies included in the survey were evaluated using a number of criteria such as the existence of privacy policies, how user information is collected and shared, and security practices.

The companies surveyed were selected based on privacy policies, collection and sharing of user information, security standards, and other criteria. Google ranked #1 with a score of 57 percent. Tencent, which was the only Chinese company analyzed, received 17 percent and ranked #13. The bottom three companies were the United Arab Emirate's Etisalat, South Africa's MTN, and Russia's Mail.Ru, which received 14 percent, 14 percent, and 11 percent respectively.[48]

Consider Etisalat, which as of 2014 operated across seventeen countries in the Middle East, Africa, and Asia.[49] Etisalat has recently launched a number of projects to utilize BD and the cloud. In January 2016, Etisalat shut down Egypt's access to Free Basics, which is Facebook's zero-rated Internet services offering, which is an encrypted service. It was believed that the restriction was requested by the Egyptian government in order to silence dissents just before

the anniversary of the 2011 uprising and the Mubarak regime's fall on January 25. Etisalat had also shut down the Internet in Egypt in 2011, along with other telecommunications companies Orange and Vodafone. However, unlike Orange and Vodafone, Etisalat did not join the Telecommunications Industry Dialogue on free expression and privacy and it did not respond to Human Rights First when questioned about the incident. In Morocco, Etisalat had shut down Viber in the past. It was reported that Etisalat received zero credit in the Index on network security. The company does not disclose anything about its standards for encryption and security in its products and services.[50]

In these countries public policy agencies such as central banks are indifferent towards privacy protection. For instance, in 2013, the Bank of Russia fined the LSE-listed Russian Internet company, Mail.ru Group, $15,000 for refusing to provide data on users' personal messages. The Bank had requested the Mail.ru Group to provide information regarding Mail.ru users' correspondence. Mail.ru had refused to provide the requested information arguing that the Russian Constitution protects private personal correspondence.[51]

3.4 Measures Taken at Various Levels to Strengthen Security and Privacy in Developing Countries

International organizations, governments, NGOs, and private sector actors in developing countries are directing more efforts towards strengthening data privacy and CS issues. A 2016 survey by the UN Conference on Trade and Development found that more than half of all developing countries still lacked national legislation to protect data and privacy online. In addition, many countries have legislation that needs to be updated and/or better enforced.[52]

3.4.1 International Institutions

There is no globally accepted instrument to address the concerns related to data protection and privacy. The current system for data protection is highly fragmented, with diverging global, regional, and national regulatory approaches.[53] At the same time, various measures are being taken at the international level to address this situation. For instance, the African Union Convention on Cyber Security and Personal Data Protection requires member states to establish a legal framework for the "protection of physical data and national Data Protection Authorities" (DPAs).[54] Other regional initiatives include agreements by the European Union, the Asia-Pacific Economic Cooperation and the Commonwealth. At the global level, the Council of Europe Data Protection Convention of 1981 ("Convention 108") is the most prominent binding international agreement on data protection.[55]

3.4.2 National Governments

As a response to domestic and international pressures to build CS measures, in July 2013, the Government of India released the National Cyber Security Policy (NCSP). The NCSP outlines the basic policies and strategies "to build a secure and resilient cyberspace for citizens, businesses and government."[56] It set forth fourteen objectives that included enhancing the protection of critical infrastructure and developing 500,000 skilled CS professionals in the next five years.[57] The development of public–private partnership (PPP) efforts towards enhancing the CS is a key component of the NCSP. Note that PPPs are especially well-suited and justified for areas that require diverse types of expertise and knowledge in order to address complex problems.[58] This condition fits squarely with CS.[59]

Some economies are implementing policy measures that require companies to establish local data centers. For instance, the Central Bank of Nigeria (CBN) prevents storing certain categories of financial information and data outside the country.[60] South Africa's new rules prohibit sending personal information to countries that do not provide the same level of protection to such information as the country's strict privacy laws.[61]

It is important to discuss the importance of CS vis-à-vis privacy. It is reported that, in some developing economies, while there has been an increasing awareness, understanding, and knowledge about CS and they have exhibited a higher degree of preparedness to address CS problems, there is the lack of regulatory and enforcement capacity for privacy protection. For instance, in Rwanda, for government organizations dealing with ICTs such as Rwanda Development Board (RDB) and Rwanda Utilities Regulatory Authority (RURA), Rwanda National Police (RNP) were reported to have departments that deal with cybersecurity and cybercrime. Nonetheless, data protection has not received serious consideration among these agencies. There has also been the lack of laws to safeguard data privacy. These agencies do not have specific institutions that are specially designated to look at data privacy issues.[62]

On the other hand, some countries have focused their attention more on privacy compared to CS. For instance, Saudi Arabia has some laws related to privacy and data collection, but it lacks mechanisms to ensure data security or notification of data breaches.[63]

3.4.3 Professional and Trade Associations

As important sources that shape institutional structures in an economy, professional and trade associations play significant roles in bringing and legitimating institutional changes in the areas of security and privacy in BD and the cloud environments.[64] In order to understand professional and trade associations' roles in shaping a nascent industry in a developing economy (e.g., BD and the cloud),

it is important to examine such associations in relation to other institutional elements—most notably, the state. Note that the state is arguably the most important institutional actor.[65] With regard to the state's role in influencing industry behavior in emerging economies, however, it is important to note that the rule of law is "often weakly developed" or sometimes "ignored with impunity" in such economies.[66] Second, in nascent and formative sectors such as BD and the cloud, there is no developed network of regulatory agencies comparable to established industrial sectors.[67] In such settings, professional and trade associations may emerge to play unique and important roles in shaping the industry.

India's Data Security Council of India (DSCI), an industry body, entered into a partnership with Pearson VUE to deliver a data privacy credentialing program: DSCI Certified Privacy Professional (DCPP). The certification is expected to address the need for privacy professionals in the country. DCPP equips individuals with the necessary privacy-related skill sets. Individuals with the DCPP certification will be aware about privacy-related concepts and principles and the data privacy landscape in India and other economies. They will also learn about contemporary global developments in privacy-related matters, data protection regulations, and trans-border data flows.[68]

In India, a report by the Internet & Mobile Association of India (IAMAI), a not-for-profit industry body, argued against a mandatory requirement to set up data centers in India. It maintained that data location requirement is likely to harm Indian companies. The report cited many examples of Indian companies that rely on international data centers. For instance, Zoho's data centers are in California and New Jersey. Myntra and Redbus host servers with CSPs such as AWS. Likewise, in the beginning Flipkart relied on data centers in Canada.[69]

In some countries, Internet companies are directing more efforts towards strengthening CS. In China, an e-commerce union has been formed, whose members comprise of major online firms. The union analyses vendor data such as those related to transactions and other sales activity in order to identify rogue online vendors.[70]

3.4.4 Providers of BD and the Cloud

Developing world-based providers of BD and the cloud are taking measures to strengthen security. For instance, as of 2014, China's Aliyun was reported to have a 100-plus personnel team to provide cloud security.[71]

3.4.5 Organizations and Consumers Using BD and the Cloud

CUOs are increasing their orientation towards security and privacy. According to a survey released in 2013 by Ernst & Young Global Limited, which was conducted among Indian firms, 69 percent of respondents were planning to

strengthen CS.[72] Likewise, as noted earlier, *China Youth Daily*'s poll showed that over three-quarters of respondents believed there was abuse of BD.[73]

3.5 Concluding Comments

The examples related to the attacks on Aramco and RasGas are illustrative of a widespread problem not only in GCC economies but also in all other economies, including developing economies. Organizations and consumers in developing countries face unique risks and challenges related to privacy and security in the BD and cloud environments.

Despite some initiatives, limited international cooperation on privacy and security issues exists among developing countries. For instance, while the African Union (AU) adopted its Convention on Cybersecurity and Personal Data Protection in 2014, only eight of the fifty-four members of the AU had signed the Convention as of July 2016. By that time, no country had ratified the Convention.[74]

The actions of Etisalat and many other companies involved in handling personal data indicate that the lack of privacy and security is often the product of the thoughtless and indifferent attitudes of these companies towards these issues. There thus remains a notable lack of institutionalization of privacy and security issues among most firms handling consumer data in developing countries.

From the privacy and security standpoint, BD and the cloud are likely to affect the welfare of unsophisticated, vulnerable, and technologically unsavvy consumers more negatively. Such consumers may lack awareness of multiple information sources and are less likely to receive up-to-date and accurate information about multiple suppliers in a manner that facilitates effective search and comparisons. They are also not in a position to assess the degree of sensitiveness of their online actions and are more likely to be tricked by illicit actors. Consumers in developing countries are more likely than those in developed countries to exhibit these features and profiles.

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PART II

Big Data and Cloud Computing in Key Development Areas in the Global South

4

PRIMARY INDUSTRIES

4.1 Introduction

Primary sectors remain dominant in most LDCs. This sector, however, is a laggard sector in the adoption of new technologies. For instance, according to Wolfgang von Loeper, a former farmer, and the founder of MySmartFarm app, the average African smallholder farmer produces only a quarter to half of the productive potential.[1] This low productivity of smallholder farmers is attributable to their low rate of adoption of modern technologies. For instance, the Indian BD and cloud market for agriculture—despite some signs of progress—remains relatively backward compared to some other developing countries. The agricultural sector in India has not received the attention that it needs and deserves. For instance, fruits and vegetables worth US$2 billion are wasted annually in India due to the lack of supply chain management and cold storage facilities. The agricultural sector is characterized by extremely low investments in modern ICTs. For instance, in 2015, US$6 billion was invested in tech start-ups, of which agriculture start-ups attracted less than 1 percent of the total.[2]

Several benefits have been identified that BD and the cloud can offer to the primary sector. For instance, just like in computer chips and other sophisticated industries, sensors in primary industries such as agriculture, oil and gas, and pulp and paper can be used to take detailed readings on process conditions. Based on the readings, automatic adjustments can be made in order to reduce waste, downtime, and human interventions.[3] According to Monsanto, the world's biggest seed company, tailoring information and advice to farmers could increase annual worldwide crop production by about US$20 billion.[4]

In the oil and gas sector, conditions of machines and equipment can be monitored, which can result in more effective maintenance and inspection based on

industry as well as historical and real-time data. Early warnings from sensor data can help replace planned maintenance with preventive maintenance, which can reduce downtime. Instant information from oil wells can provide information to make timely decisions on underperforming wells. Detection of anomalies while drilling as well as during operation can lead to more effective decisions for cost savings.[5]

Nonetheless, the transformative potential of BD and the cloud has not yet been realized in the primary sectors. For instance, an observation is that the oil and gas industry is not among early adopters of digital technologies.[6] BCG's Grant McCabe, who is the team leader for "next-generation mining" noted: "There is enormous slack in many mining systems. The industry has not been run with manufacturing discipline."[7] Only a small proportion of firms in the oil and gas sector are actively using the BD. For instance, according to research by DNV GL, one in five UAE oil and gas companies considered themselves to be highly digitalized.[8]

Mining companies are increasingly adopting what is referred to as "the next generation of underground mining."[9] An article published in the *Financial Times* in 2014 explains how miners located half a kilometer below ground at Chelopech in Bulgaria use tablets to feed data, which is analyzed by a control room on the surface to make decisions on a real-time basis.[10] The mine's owner, Dundee Precious Metals, installed 45 km of fiber optic cable in order to build an underground WiFi network.[11]

Surveying of potential oil drilling sites involves monitoring seismic waves moving through the earth. At a spot being surveyed, the patterns are examined to see if the waves are distorted as they pass through oil or gas. In the past, a few thousand readings were taken at a potential drilling site. Advancements in BD analytics and other technologies have made it possible to increase the number of readings to more than one million. This increases the accuracy of images of sites. Shell uses fiber optic cables to analyze the data generated by sensors. The data is transferred to its cloud servers, maintained by AWS. Data from a potential oil field is compared with thousands of other sites around the world in order make more accurate recommendations regarding the sites to drill. Production forecasting, which entails estimating the likely output of a reservoir, determines the resources that should be spent on collecting it. Data-led decisions allow operators to have more confidence regarding the efficiency with which oil can be extracted. Shell also uses BD to ensure that machines are working properly, which minimizes breakdowns and failure. This is especially important as oil drilling machines operate in adverse conditions for long periods of time, which increases the probability of wear and damage.[12] The machines are fitted with sensors, which collect data about various performance indicators.[13]

How the adoption of BD, cloud, and other related technologies in the primary sector, especially among smallholder farmers, can be accelerated in order to increase productivity is a pressing policy issue that adjoins larger political

and social concerns of national governments, donor agencies, and other relevant actors. The significance of this issue also stems from the fact that primary sectors can assist to maintain the resilience of the economic system of developing countries. During the first half of 2009, the export from LDCs declined by over 43 percent compared to the first half of 2008. The market for primary commodities was among the first to rebound. During 2007–2008, primary commodities including fuels accounted for 80.6 percent of merchandise exports by LDCs.[14] Likewise, a distinguishing feature of the South–South economic relations is that the flows of trades and investments among these economies are concentrated in the primary sectors. For instance, the majority of investments in Africa from BRIC economies are in these sectors.[15]

4.2 Some BD- and Cloud-Based Applications in the Primary Sector

A number of different BD- and cloud-based applications have been developed and deployed in the primary sector of developing countries. As noted above, tools such as Maana's "Enterprise Knowledge Graph" allows data analysts, business analysts, data scientists, and enterprise architects in an organization to collaborate.

In the agricultural sector, we noted in Chapter 2 that BD- and cloud-based mobile computing apps such as iCow and AgriLife have led to increased productivity of traditional sectors such as agriculture and farming. Some of the apps also helped create the market by providing near-real-time information on farmers' ability to pay for services to financial institutions and suppliers.

Bengaluru, India-based Flybird Agri Innovations' Smart Irrigation Controller (Siri), deploys sensors in the soil to detect moisture content and take measures to prevent under or over irrigation and fertigation. It is reported that Siri helps save water by 25–30 percent.[16] As of April 2016, Flybird's sensors were installed in forty-five villages in Karnataka to help farmers optimize irrigation.[17]

Another example that provides a platform in the agricultural sector is Springg, which is based in Wageningen, the Netherlands and Istanbul, Turkey. Springg's social media environment can link individual farms with other similar farms. Suppliers can create apps in order to deliver value to their customers by linking their services to relevant data.[18] Its app SoilCares provides insight on nutrients and soil composition and provides advice that can be implemented to fertilize crops. It is claimed that productivity can be increased by up to 500 percent.[19]

Springg's mobile test centers collect local soil data with sensors and run soil analyses on site. Local farmers can get immediate results on soil conditions and make decisions regarding the best fertilizers for crops. Soil data is then sent in to a centralized database and analyzed further to extract additional information.[20] Among over 500 million farmers in the world, only about 20 million can afford

testing of soil samples using traditional laboratories. Such labs are often located in urban areas and cost thousands of dollars.[21]

As of December 2015, over 25,000 farmers had used the SoilCares system.[22] For example, a farmer in rural Kenya was able to reduce fertilizer costs by US$100 in six months and increased his crop yields fourfold.

Apps have also been developed for the forestry and fishing sector. Global Fishing Watch uses data and mapping to deal with environmental problems such as deforestation, illegal waste dumping, and oil spills. The Pew Charitable Trust's Eyes on the Seas project combines satellite data, fishing vessel, and other information to help authorities monitor fishing activity. Likewise, Global Forest Watch uses a wide variety of data to spot illegal logging or other activities that damage forest resources. Public platforms such as Global Fishing Watch enable anyone to act as a watchdog and to report environmental crimes. Such activities can press companies to engage in appropriate behavior and governments to pass and enforce environmental laws.[23]

NGO Oceana, the non-profit environmental mapping service SkyTruth, and Google have teamed up to develop the Global Fishing Watch public platform, which shows the location of fishing vessels. By checking AIS data used in tracking ships and vessel traffic services, it can be ensured that fishing ships do not enter banned or restricted areas. The data can be used to improve knowledge about illegal fishing. According to the United States National Oceanic and Atmospheric Administration, 40 percent of the catch in some fisheries are illegal, unreported, or unregulated (IUU). While activist organizations such as Global Fishing Watch are taking initiatives to track environmental offenses, they face a number of difficulties. For instance, vessels may turn off their AIS transmitters. Buyers, however, could force fishing companies to become more compliant by insisting that their fish comes from vessels that have their transmitters operational at all times, thus being transparent about where they are fishing.

4.3 Key Driving Forces in the Adoption of BD- and Cloud-Based Applications in the Primary Sectors

A number of forces have come together to drive the adoption of BD and the cloud in the primary sector.

4.3.1 Relevant Policy- and Decision-Makers' Interest in BD and the Cloud

Developing countries' policy and decision makers in primary sectors have put BD and the cloud high on their organizational and national developmental agenda. They are gaining a better understanding of the transformative potential of BD and the cloud. For instance, according to the above noted study conducted by DNV GL in the UAE, over half of senior oil and gas professionals in

the country saw BD's high potential to transform the operating efficiency of the industry.[24]

In order to improve efficiency in the mining industry, Kazakhstan signed a deal with Google and McKinsey to utilize BD in the industry. Kazakhstan wants to become a pioneer in the BD deployment to improve the efficiency of the country's mines. Kazakhstan has established a "mining industry competence center," which gathers data from sensors within mining and processing equipment located in different parts of the country. The use of real-time data allows companies in the industry to identify bottlenecks and improve efficiency.[25]

In a benchmark study of the oil and gas industry commissioned by industry advisor DNG VL, which was released in early 2016, most survey respondents were of the view that digitalization would have a significant impact on the oil and gas sector in 2016. Among the most prominent technologies identified the respondents included: unconventional gas extraction technologies (20 percent), BD analytics (16 percent), the IoT/smart technology (15 percent), and digital oilfields (15 percent).[26]

4.3.2 BD- and Cloud-Related Investments in the Primary Sector

Investments in BD and cloud technologies are flowing from the public as well as private sectors. For instance, India's meteorology office uses a statistical method introduced in the 1920s under the British colonial rule. In June 2016, India announced a plan to spend US$60 million on a new supercomputer system in order to improve the accuracy of weather forecasts. The new system generates three-dimensional models to predict the monsoon's development. Some experts think that better forecasting could help India boost farm output by as much as 15 percent by helping farmers make decisions regarding the best time to sow, irrigate, or apply fertilizer.[27]

There has been a rapid increase in investment activity in agri-technology. The amount of investment in the agri-technology sector was US$500 million in 2010, which increased to US$4.2 billion in 2015 according to AgFunder, the online investment site.[28] In the first half of 2015, agricultural technology (agtech) raised US$2.06 billion in venture capital investment in 228 deals. Precision agriculture technologies such as drones and satellite imagery attracted US$400 million.[29]

Firms in the oil and gas industry are also engaged in investment and business activities in order to strengthen their BD ecosystem. In mid-2016, Saudi Aramco Energy Ventures led a Series B funding round of US$26 million for the US-based start-up Maana, which specializes in BD search engine platform to help Fortune 100 companies in industries such as oil and gas, manufacturing, health care, and insurance to maximize the use of their information.[30] Other major gas and oil investors such as Shell Technology Ventures and Chevron Technology Ventures also participated in the funding round. Using Maana's

"Enterprise Knowledge Graph," data analysts, business analysts, data scientists, and enterprise architects in an organization can collaborate in a single, integrated system.

4.3.3 The Roles of the Transnational Corporations (TNCs)

In one way, transnational corporations (TNCs) are likely to be a driving force behind the diffusion of cloud and BD in the primary sector of developing countries. For instance, large food and biotechnology TNCs such as Monsanto and Syngenta already have a notable presence in developing countries, which is a positive factor from the standpoint of BD-led productivity growth in these countries. During 2005–2007, the share of agriculture in FDI inflows was 15.1 percent in Cambodia and 12 percent in Laos.[31] Monsanto reportedly has control on over 95 percent of the Indian cotton seed market.[32] TNCs, which are often producers, processors, or traders of agricultural products or sellers of inputs or machinery, engage in a contracting system in which they assume a variety of responsibilities including providing technical assistance and marketing to developing world-based small farmers.[33] NCs such as Monsanto and Syngenta, which have become a driving force behind the utilization of BD in the industrialized world, are thus likely to act as a key channel in the international technology transfer of BD.

A typical offshore oil production platform is estimated to have over 40,000 data tags. However, not all of them are connected or used. In order to convert to making better business and operating decisions using the data sets, new and carefully designed capabilities for data manipulation, analysis, and presentation are required. In addition, tools to support decision-making are needed. One estimate suggested that if production efficiency of a brownfield oil and gas service company is improved by 10 percent, profitability will increase in the US$220 million to US$260 million range. Digitization can also extend field life. Even higher potential could be achieved in greenfield assets by including instrumentation from the start.[34]

Global technology providers have become an even more important force in driving the adoption BD and cloud in the primary sectors in the developing world. In mid-2016, Microsoft opened its biggest center of excellence for the oil and gas industry in Dubai. The center seeks to help organizations in the oil and gas sector to utilize the latest technologies such as the IoT, BD analytics, and cloud computing using Microsoft Azure and Office 365.[35]

4.3.4 The Roles of International Agencies

In some countries, international agencies have been the driving force behind the adoption of BD and the cloud. For instance, Haiti's Ministry of Agriculture has strengthened its knowledge management system through its adoption of

cloud technology. This project is funded by the World Bank and makes Haiti's agricultural infrastructure, which was destroyed by earthquake in 2010, resilient to natural disasters.[36]

4.4 Concluding Comments

Some encouraging signs have emerged to suggest that the adoption of BD and the cloud are likely to get a big boost in the primary sectors of some developing countries. Among the most encouraging factors is the rapid increase in investment in this sector. For instance, as noted earlier, agtech is one of the sweet spots for VC investors. The VC investments are likely to lead to the development of technologies that are likely to benefit smallholder farmers. As noted above, policy and decision makers in these sectors are gaining a better understanding of the transformative potential of BD and the cloud.

Agtech companies are developing new and cutting-edge innovations in BD and cloud computing that are likely to facilitate smallholder farmers' adoption of these technologies. Technologies and apps such as iCow, AgriLife, and SoilCares systems have helped overcome the various barriers that smallholder farmers confront in the adoption of new technologies to increase farm productivity.

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5

EDUCATION AND R&D

5.1 Introduction

Just like the primary industries discussed in Chapter 4, education is often considered to be a laggard sector in the adoption of new technologies.[1] In recent years, this trend has changed. According to Markets and Markets, the global cloud computing market in education will grow from US$5.05 billion in 2014 to US$12.38 billion by 2019.[2] BD and the cloud are playing the central role in R&D and educational system in developing countries. For instance, South Korea's Ministry of Education, Science and Technology is implementing a program that will turn the nation's classrooms paperless by 2015. This program will provide each student with a tablet and access to textbooks and other educational materials from a cloud computing system.[3]

Before proceeding further, it is important to note that the conventional learning environments suffer from several limitations such as the lack of immediate feedback to students, requirement for teachers to spend many hours grading routine assignments, and failure to take advantage of digital resources in order to improve the learning process. A complaint that is often made is also that there are a number of drawbacks in the system of recruiting, training, supervising, and monitoring teachers in developing countries. There is arguably the lack of proactivity of teachers to show students how to improve comprehension. It is also argued that the education system is mainly input driven. The management of the education system at best focuses exclusively on logistical targets such as money spent and construction of schools. There is often no environment to provide support or incentives to produce high learning achievement.[4] Other challenges that have affected the quality of education in developing counties include high rate of teacher absenteeism, the role of political

patronage in the hiring of teachers, low technical quality, and the ineffectiveness of teacher training.[5]

The upshot of these tendencies is that a large proportion of children and youths in developing countries are deprived of educational opportunities. For instance, in Africa, thirty million children fail to attend primary school education.[6]

Some of the above-mentioned problems can be addressed by BD- and cloud-based learning solutions. For instance, Bridge International Academy, which provides e-learning solutions claimed that its tools have reduced unexcused teacher absenteeism to less than 1 percent.[7] Technology use would lead to better monitoring and control. If a teacher fails to sign into the tablet, Bridge can call the teacher to find out the reason. Data-driven approaches make it possible to analyze learning in real-time and offer systematic feedback to students as well as to teachers.[8]

BD and the cloud have also facilitated R&D activities in developing countries. For instance, thanks to the cloud, it has been possible to have supercomputer power to access educational resources and to analyze data on disease spread pattern and climate changes.[9] Likewise, Yahoo! has collaborated with the Indian Institute of Technology Madras (IIT-Madras). It established a Grid Computing Lab, which allows researchers to access and conduct research on BD and cloud computing.[10] To take another example, scientists at University of Washington's Center for Infectious Disease Research and India's Goa Medical College used cloud computing and BD to conduct research into factors that make some malaria cases severe and life-threatening. The research team analyzed data on sixty patients using advanced computing techniques to find relevant patterns. The project analyzed fifty parasite binding proteins and additional variables for each of the patients. Finding patterns in a large number of variables required the use of machine learning and other computing techniques.[11]

BD and cloud computing have allowed African biomedical researchers to conduct R&D on diseases such as HIV/AIDS, tuberculosis, malaria, and tropical diseases. Note that these Africa-specific diseases are often ignored by Western pharmaceutical companies.[12] The Computational Intelligence Research Group at the University of Pretoria uses the cloud for medical research—in particular, to help develop drugs for treating serious illnesses specific to Sub-Saharan Africa.[13]

5.2 BD- and Cloud-Based E-Learning Tools and Systems

Imported as well as locally developed BD- and cloud-based e-learning tools and systems are rapidly transforming developing countries' educational landscapes. BD and the cloud are being deployed at all levels of educational situations. In this section, we briefly review some of the e-learning tools and the organizations involved in developing them.

5.2.1 BRCK's Kio Kit and Kio Tablets

Kio tablet and the Kio Kit ("Kio" is Swahili for mirror) are the flagship products developed by the Kenyan technology company BRCK.[14] Kio Kit is also referred to as a digital classroom in a box, which is a tablet learning system designed to work in a rural African classroom. The Kio Kit includes forty customized tablets, forty earphones, a router and a plug to provide wireless charging in a 40 kg rugged case.[15] The system is a self-powered mobile WiFi device, which is managed via a cloud-based interface.[16]

The Kio Kit tablets are pre-loaded with the Kenyan curriculum and international contents. They also contain web-based content, videos from local providers such as Kenya's eLimu, local edutainment broadcaster Mediae (its Know Zone programs), eKitabu, a Kenyan e-book company and Tanzania's Ubongo Media, and international organizations such as Pearson, TED-Ed and Khan Academy.[17]

The system was designed in Kenya and is equipped with a sim card and Internet connectivity. However, when the devices are provided to students, they are not connected to the Internet, which means that students cannot look at non-educational contents. New materials can be updated on the tablets when they are connected to BRCK. The Kio Kit houses a web server also referred to as "micro-cloud," which is an offline version of the Internet. It provides rich, interactive content available on the web but users do not need to pay expensive data costs.[18]

The Kio Kit is encased in a tough, water-resistant plastic container, which also acts as a charger when the tablets are stored. The whole unit can also be charged from a wall outlet, solar power, or a car battery.[19]

The seven-inch Kio tablet is breakproof for up to a 70 cm drop on a concrete floor. It can also survive occasional water spills and dust exposure. It has a scratch resistant screen coating and rubber outer shell.[20] BRCK Kio Kit won the *Stuff Magazine*'s "Educational Tech of the Year" Award for its innovative design.

New materials are uploaded on the BRCK wirelessly during the night when more bandwidth is available. The materials are then shared with the tablets during classes.[21] A teacher thus can take the Kio Kit home and download the lessons for the next day if there is no connectivity in the school.[22] In remote areas that lack Internet access or where Internet access is expensive, updates are made by a technician in person.[23]

BRCK runs on an open source Linux server, which reduces the costs. Each kit costs US$5,000.[24] As of 2015, BRCK was working with local Chase Bank in order to offer a twelve monthly payments plan to buy the kit.[25]

It was reported that BRCK was bought by customers in Europe and the USA. The African Wildlife Foundation and the European Council of International Schools had also shown interest in BRCK.[26]

5.2.2 Bridge

As of 2014, Bridge International offered three years of early childhood education, and seven years of primary education (Classes 1–7).[27] Bridge utilizes BD, algorithms, and a scripted-learning education methodology. Bridge was opened in Kenya in 2008. Seven Bridge International Academies were opened in Uganda in February 2015 and two were opened in Nigeria in September 2015. As of 2015, Bridge had 414 schools across three countries.

As of September 2015, Bridge served about 120,000 students. It has a huge amount of data on its students. The longitudinal data on children captures their developmental process. Thanks to the value and insights provided by the data, Kenya's Ministry of Education was reported to be reconsidering the regulatory framework.[28] The goal is to reach 10 million children by 2025.[29]

Bridge opened a London office in 2015. Bridge was awarded WISE Awards for innovation in education. WISE inspires girls and women to study and build careers in science, technology, engineering, and mathematics (STEM).[30]

In 2015, an Indian expansion team was founded. It was reported that Bridge expressed an interest in partnering with the Andhra Pradesh government.[31] Bridge's plan was to launch in India in the 2016/2017 academic year.[32]

In March 2016, the Liberian education minister announced that the country's entire pre-primary and primary education system would be outsourced to Bridge. Under the public–private arrangement, Bridge would pilot the program in fifty public schools in 2016 and design curriculum materials. Phase two involves the rollout of mass implementation over five years.[33]

The Internet and Barnes & Noble's Nook tablets are used to deliver lesson plans. Teachers are provided with tablets, which are used for instruction, assessment, and data-gathering.[34] The tablets are used to collect test results from students, which serve as a means of monitoring progress.

Teachers check in via their tablets when they arrive. They run lessons almost verbatim from the tablet's scripts, which are data driven. The data is compiled and analyzed at Bridge's Nairobi offices and Massachusetts-based headquarters.[35]

Bridge argues that the use of technology and standardized procedures enhance the quality of education it offers.[36] It has attracted diverse investors. The California-based venture-capital firm Learn Capital LLC is Bridge's largest shareholder in with a 15 percent stake. Bridge has a plan to seek a stock market listing in NSE in 2017.[37] In March 2015, Facebook co-founder Zuckerberg invested US$10 million in Bridge.[38] In 2014, the IFC announced an investment of US$10 million in equity to support the expansion of Bridge. The UK's development finance institution CDC also announced its plan to invest US$6 million in equity. The goal was to support the company's plans to expand to more African countries.[39]

Bridge uses technology and data to manage non-instructional activities such as billing, payments, expense management, payroll processing, and prospective

admissions, which leads to a reduction in overhead costs to run an academy. These activities are automated and centralized through the Academy Manager's smartphone application and the Teachers' tablet application. A Bridge International Academy has only one employee in management: the Academy Manager (the "principal"). Bridge argues that a high degree of digitization means that the Academy Manager can focus on more critical works that must be executed locally such as overseeing classroom instruction and managing relationships with parents and the local community.[40]

It was reported in 2014 that the company was developing software, which analyzes previous test scores and levels of participation so that teachers know the students that need to be called on for a specific question.[41] In this way, the system is output rather than input focused.

Bridge also ensures 100 percent teacher attendance with a pool of on-call substitutes and other measures. Note that in Kenya, teachers have an absenteeism rate of 47.3 percent in government schools and more than 30 percent in private schools.[42]

Bridge charges a tuition fee of US$6 a month. It does not accept cash. Parents can pay by smartphone.[43]

5.2.3 DreamBox

DreamBox uses game technologies and immersive math courseware in order to make learning more fun and interesting. Algorithms adapt the learning experience to a student's needs. Brilliant.org makes it possible for talented students in mathematics and physics to learn at their own speed. Its global massive online open courses (MOOCs) use social networks, videos, and community interactions to offer university-level classes.[44]

5.2.4 Eneza

Eneza Education has developed a mobile platform, which utilizes BD and the cloud to offer students access to quizzes, mini-lessons, and other educational contents.[45] For instance, a student who wants to take a math quiz texts a code. The system texts back the student with math topics based on the national curriculum. The student selects the topic, and is then texted back with five multiple-choice questions. After the student finishes the quiz, the system provides feedback on the answers. Eneza also allows users to search Wikipedia using SMS. Students can also ask a teacher questions. Teachers can monitor their students' performance through their accounts.

Schools can pay US$180 annually to have access to student data and teaching resources. Parents can get similar accounts for about US$15/year. Using the Eneza platform, students, teachers, parents, and school leaders can communicate with each other.

As of mid-2015, Eneza had more than 300,000 students from over 700 schools in Kenya and over twenty schools had subscribed its data.[46] By early 2016, Eneza was operating in Kenya, Tanzania, and Ghana and it plans to launch in Nigeria and South Africa in 2017.[47]

Some of the key challenges faced by Eneza in rural areas include the lack of devices and the difficulties of establishing and maintaining relationships with mobile network operators.[48] As of 2013, thanks to a partnership with Safaricom, the cost of taking a five-question test was three Kenyan shillings (about US$0.03). Before the partnership, the cost was twenty Kenyan shillings (about US$0.23). Eneza wants to reduce the costs of its services to students. The company is developing other revenue streams such as selling data via subscription to schools, the government, and other stakeholders, interested in knowing students' performance.

5.2.5 Coursera

Coursera is a MOOC platform, which provides cloud-based education by offering courses in science, math, medicine and other areas. The goal is to help students gain market-relevant IT skills.[49]

The World Bank's New Economy Skills for Africa Program (NESAP-ICT) and Tanzania's Commission for Science and Technology (COSTECH) partnered with Coursera to launch an initiative to incorporate Coursera offerings to pilot the Youth Employment Accelerator Program Initiative (YEAPI).[50]

In 2013, as part of its Global Learning Hubs program, the US Department of State's Bureau of Educational and Cultural Affairs facilitated discussion to offer Coursera courses on a number of subjects in over thirty countries including China, India, Tunisia, Georgia, and Bolivia.[51]

In June 2016, Coursera and the Indian School of Business (ISB) announced the launch of four courses on "Financial Markets and Investment Strategy." The ISB had offered on Coursera's MOOCs platform for the first time in 2014.[52] As of 2015, 40 percent of students who took Coursera classes were from emerging economies, which included 9 percent from Latin America and 4 percent from Africa.[53]

5.2.6 Advance Learning Interactive Systems Online (ALISON)

ALISON provides cloud-based learning solutions. As of mid-2016, ALISON had 1.5 million users in Africa, and half a million were active every month.[54] ALISON earns about 60 percent of revenue through certification and 40 percent by advertising.

5.2.7 Udacity

In order to address the skills gaps the Mountain View, California-based online education company Udacity works with companies such as Google, Facebook, Amazon, Github, and Cloudera to design courses. It does not consider traditional universities as a model. Most of Udacity's courses were created with at least one company's help. Companies also offer material as well as experts to help build courses and provide internship opportunities for students. They also give Udacity funding and resources. For example, Google gave Udacity US$4 million to create its Android Nanodegree[55] program, which teaches "tools, principles, and patterns that underlie all Android development."[56]

Udacity entered into India in 2015. As of mid-2015, India was Udacity's second largest market in terms of the number of students. The company was enrolling at least 27,000 students in India every month.[57]

In April 2016, it announced that it would open offices in China and make more than 100 of its free online courses available in the country under the domain name youdaxue.com.[58]

India's Flipkart has a partnership with Udacity to hire graduates based on capabilities built through, Nanodegree program. In 2016, Flipkart hired three students without in-person interviews based on their Nanodegree projects and Udacity profiles.[59]

5.3 BD and Cloud Computing in R&D

A number of notable observations are reported regarding the use of BD and the cloud in R&D activities. As we have seen above in this chapter and in earlier chapters, BD and the cloud have strongly stimulated and facilitated R&D in the developing world. For instance, EpiSurveyor (Chapter 2) has been used in research.[60] The app can be used to collect data on mobile phones. In the past, such data used to be collected using paper-based surveys. The major benefits of collecting data on mobile phones include speed, ease of use, and amenability to modification in order to respond to changing circumstances. Moreover, collected information can be automatically processed and analyzed.[61]

Here we briefly illustrate and summarize the use of BD and the cloud in two key developing countries: Brazil and South Africa.

5.3.1 Brazil

Brazil's universities and research institutes are using public as well as private cloud services. As of 2015, the Brazilian research and education network Rede Nacional de Ensino e Pesquisa (RNP), which is Brazil's academic Internet backbone, connected about 350 public and private universities and research institutions through a national backbone.[62] RNP's data center also hosts its

partner institutions' applications including a web portal offering access to a large number of international scientific journals.[63]

5.3.2 South Africa

Thanks to South Africa's significant investment in cyber infrastructure, the country's researchers are increasingly using high performance computing for research and education. The Centre for High Performance Computing (CHPC) was established in 2007 by the South Africa Department of Science and Technology (DST). The CHPC's BD-related activities include providing training to data scientists, supporting research projects using BD, and facilitating researchers' participation and collaboration with international networks. The South African Research Network (SANReN) provides cyber infrastructure for BD to South African universities. In collaboration with the Tertiary Education Research Network of South Africa (TENET), the SANReN has connected South African universities to fiber-based cyber infrastructure.[64]

A number of organizations have been established to deploy BD in research activities. The Nelson Mandela Metropolitan University launched the new Centre for Broadband Communication in order to conduct research around fiber optic data transport for the SKA.[65]

The radio telescope project Square Kilometre Array (SKA) is expected to facilitate the use of BD in SSA. The SKA is planned to be built in South Africa and Australia from 2018.[66] SKA's satellite dishes will cover Australia, New Zealand, and eight SSA countries. After its completion, the SKA is expected to be the world's single largest source of data. It is likely to help the host countries develop data-processing skills and enhance the BD ecosystem.[67]

Also, the Consortium for Advanced Research Training in Africa has worked with Google to develop a virtual research platform, letting nine university partners, four research institutes, and eight partners in North America, Europe, and Australia collaborate on research, manage application processes, submit online assignments, attend webinars, and participate in discussion forums.

Medical research is being combined into huge searchable databases, which make it easier to assess and compare results. By looking at databases with related prescription dosages, environmental patterns, and age-related trends, physicians can accurately pinpoint the most likely causes of a health problem such as drug, weather and humidity, or animal migration patterns.[68]

5.4 Key Drivers of BD and Cloud Deployment in E-Learning and R&D

A number of forces and trends have given rise to a rapid deployment of BD and the cloud in e-learning and R&D activities. Here, we discuss some of the key driving factors.

5.4.1 Government Initiatives

Some governments have launched programs to facilitate access to BD- and cloud-based education to the broader public. One such program is Rwanda's one digital ID per child program. The goal of the program is to provide access to digital education content via Office 365.[69]

5.4.2 Local Innovations and Entrepreneurial Efforts

Local entrepreneurial firms have been among the driving forces behind the digitization of educational activities in developing countries. BRCK is a high-profile example of a successful technology firm focusing on the education sector based in developing countries. BRCK is one of the first consumer electronics companies in Kenya. As of 2015, BRCK had sold over 2,500 devices in fifty-four countries.[70] As of March 2016, Kio Kits had been sold in schools in Kenya, Tanzania, and the Solomon Islands. There were also orders coming in from Sudan.[71]

5.4.3 Transnational Companies' Efforts

Multinational companies' efforts correlate with the development and deployment of BD and the cloud in R&D and educational activities in the developing world. In April 2016, Google announced its plan and commitment to train one million Africans in digital skills. Google supports Livity Africa to run two training programs: (1) Digify Bytes aims to provide young people with digital skills; and (2) Digify Pro is a three-month program aimed at digital specialists.[72] As of April 2016, the programs had been launched in Nigeria, Kenya, and South Africa. Google has also launched digifyafrica.com, which is an online-learning portal containing a wide range of digital skills courses that are available to anyone in Africa for free.

IBM has launched similar initiatives in Africa. In 2015, IBM announced a plan to expand its Africa Technical Academy and Africa University Program and invest US$60 million by 2017 to bridge the skills gap for technical talent in Africa. The goal of the program is to provide IT professionals with advanced skills in analytics, cloud, and BD technologies. The training and certification programs are expected to benefit 1,000 faculty members and 35,000 students in eighty universities in more than twenty African countries by 2017. In Kenya, for instance, IBM has partnered with the Kenya Education Network (KENET) in order to deliver advanced hands-on certification courses to faculty members and students in fifty universities.[73]

IBM also has similar initiatives in other countries. For instance, universities in China, Qatar, Turkey, and other developing countries have participated in the IBM Cloud Academy, which allows access to a range of educational resources.[74]

Hewlett-Packard Laboratories in India has developed a cloud-based personalized education delivery system. It provides an online school hosting service, where a virtual school can be created using the infrastructure (servers, storage, communication, and e-learning software). Its facilities include audio/video sessions or online chats.[75]

Vietnam started collaborations with IBM in 2007. In 2008, the US-based IT services company Computer Sciences Corporation (CSC) and Vietnam's First Consulting Group Vietnam (FCG) merged. CSC developed its Vietnamese operation as a center for cloud operational and support services. The University of Information Technology, a member of Vietnam National University, is using IBM PureFlex System, IBM Tivoli Service Delivery Manager, and IBM Workload Deployer to build a Smarter Computing IT infrastructure that hosts the university's virtual campus and deploys virtual education services. The cloud is used to link government agencies, universities, private-sector research, start-ups, and other organizations.[76]

As a final example, the Netherlands-based technology company Philips has teamed up with the Chinese Society of Cardiology to build the China National Cardiovascular Data Repository. Philips is also reported to be working on other databases in China.[77]

5.4.4 International Organizations

International organizations are also a driving force behind the adoption of BD and the cloud in e-learning and R&D. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) and HP's "brain gain" initiatives entail cloud use to connect students with researchers abroad. Burkina Faso's University of Ouagadougou has launched projects modeling the movement of pollutants in the Sourou River drainage basin. By 2009, successful pilot projects were carried out in Ghana, Nigeria, Senegal, and Zimbabwe. By 2011, twenty educational institutions in sixteen countries benefited from the project.[78]

In June 2016, the Government of Rwanda and the World Bank signed a US$20 million credit facility agreement to strengthen higher education, which was part of a US$140 million credit approved by the World Bank for the Eastern and Southern Africa Higher Education Centers of Excellence Project (ACE II).[79] Other countries in the region receiving similar credits include Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Uganda, and Zambia. The University of Rwanda's College of Science and Technology would host a multidisciplinary center to use BD by combining expertise in statistics, economics, business, computer science, and engineering.

Capacity Kenya, a USAID funded project, in collaboration with the Kenya Medical Training College and Africa Medical and Research Foundation, has hosted a local cloud environment that is used to locate and map healthcare specialists and develop virtual learning platforms for medical students.[80]

5.4.5 International Collaborations

International collaborations and development of research capacity are some of the initiatives underway in developing countries to overcome resource challenges. For instance, CLR's EKA supercomputer, which was the world's fourth fastest in March 2009, was used for joint cloud research with Yahoo.

South African researchers have engaged in BD partnerships that include international public and private institutions. Some notable partners include the UK's Cambridge University; and the Large Hadron Collider ATLAS (**A** **T**oroidal **L**HC **A**pparatu**S**)[81] and A Large Ion Collider Experiment (ALICE) at the European Organization for Nuclear Research (Conseil Européen pour la Recherche Nucléaire in French) (CERN) and the pan-European data network for the research and education community, Geant.[82] The Human Heredity and Health in Africa (H3Africa) focuses on bioinformatics-related research in collaboration with Cambridge. Similarly, the UbuntuNet Alliance, which is a platform for the AfricaConnect project, connects African countries to Geant. This allows South Africa to participate in large science projects in order to pursue data-intensive scientific discovery.[83] Likewise, China Telecom has teamed up with Cambridge University in research involving M-health.[84]

5.5 Discussion and Concluding Comments

BD and the cloud are likely to address some of the challenges related to education and R&D in developing countries. A number of encouraging signs have emerged to suggest that BD and the cloud can transform the R&D and educational systems in developing countries. E-learning tools such as Kio Kit epitomize the evolving role that BD and the cloud can play in enhancing educational outcomes.

The above discussion suggests that uses of BD and cloud in education are driven by philanthropic and charitable causes as well as motivated by profit-oriented behaviors. Various platforms used have different levels of sophistication of technologies. Some platforms have been developed specifically for the developing world while others have been exported to developing countries following successful implementation in industrialized countries.

Nivi Sharma, president of BRCK Education noted that the use of e-learning solutions is only 20 percent technical such as switching on, accessing contents, and navigating different sections. According to her, socializing teachers is about 80 percent of the challenge, which entails motivating them to think differently about the teaching and learning approaches.[85]

The above said, BD- and cloud-based learning solutions currently have a number of drawbacks and limitations. It is argued that teachers are "barely trained, unqualified, poorly paid." Students do not have access to their own tablets. Teachers are expected to all read the scripts aloud word-for-word and

the contents are delivered on the tablet at the same time in each school every day. This "teacher turned-robot" would not be tolerated in most schools in most developed countries.[86]

Kio Kit and Eneza are based on less sophisticated technological solutions, which are well-suited in the context of LDCs. In a developing country, a company's success depends on its ability to reduce costs. For instance, Eneza is exploring a number of revenue streams in order to reduce the costs of student access. In addition, the systems need to consider the unique situations facing developing countries. For instance, the Kio Kit is drop, dust, and water resistant.

A less discussed benefit is that the availability of a complete digital record of students' achievement and performance significantly reduces the time to hire and recruit for potential employers. For instance, Flipkart's hiring decisions were based solely on the candidates' Nanodegree projects and Udacity profile.[87] In this way, Flipkart has eliminated the in-person interview for well-qualified students in Udacity's Nanodegree program.

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6

E-COMMERCE

6.1 Introduction

Prior theory and empirical research on diffusion and adoption of e-commerce argues that firms based in developing economies face more barriers and obstacles to e-commerce utilization than those in industrialized countries.[1] BD and the cloud have been touted as a key mechanism for leveling the playing field for firms in developing economies, especially SMEs.[2]

A key benefit of the cloud is that it helps to cut IT costs. The cloud also allows firms to benefit from a number of technologies without requiring a deep knowledge and expertise about the technologies' underlying principles and concepts. This means that firms can focus on their core businesses instead of being impeded by technical difficulties and obstacles. Such benefits are of special value to firms in developing economies due to a number of economic, technological, and cognitive barriers they face in acquiring and using e-commerce technologies.

Most SMEs are not in a position to buy servers and storage and hire the IT staff to support them. The key activities associated with e-commerce such as designing websites, using search engine optimization techniques, managing email marketing campaigns, and inventory management and hiring data engineers to capture complex data requirements are prohibitively expensive to build in-house for SMEs, and even for large enterprises in developing economies. Thanks to the cloud, firms in developing economies are in a position to provide more sophisticated e-commerce-related functionalities and capabilities, complex features, and user interfaces. For instance, multi-channel e-commerce platforms provided by CSPs such as ChannelAdvisor[3] help to synchronize a retailer's e-commerce channels and its marketing strategy. It also helps the retailer to

expand to additional channels and take the e-commerce channel to the next level.[4] Likewise, the Chinese company Alibaba's AliCloud provides e-retailers with analytical data about website activities and predictions for indicators such as future sales and the products that are likely to be in high demand in the next period.[5]

Unsurprisingly BD- and cloud-based e-commerce activities are diffusing rapidly in developing economies, and serving a wide range of users and geographic areas thereby contributing to bottom lines of e-commerce firms. Consider China, the world's largest online retail market, in which e-commerce accounted for more than 13 percent of total retail sales of consumer goods in 2016. A McKinsey Quarterly article asserted that e-commerce penetration in top-tier cities is reported to be about 90 percent of Internet users.[6] Unsurprisingly, there has been a rapid growth of data related to a number of indicators such as online shoppers, stock keeping unit (SKU) of products, response to price changes, promotional performance, and purchase habits of online shoppers. China's major e-commerce players are using this data to build models in order to increase customer spending and retention. For example, BD can help segment and identify customer groups at different life stages and target offerings in order to increase sales. Some e-retailers are also reported to be using machine learning to make decisions related to product lines and promotional activities.[7]

In some developing economies, BD- and cloud-based e-commerce activities are expanding from Tier 1 cities to smaller cities and villages. For instance, the Indian e-retailer Jabong.com, which uses cloud offerings from Oracle, Adobe, and other CSPs,[8] receives 60 percent of its revenues from smaller towns.[9] In 2012, Alibaba announced that its cloud-based app, Alipay, had established a rural business unit to reach non-e-commerce users in third- and fourth-tier cities and in rural areas.[10]

The evolution of cloud-based e-commerce has been a key driving force behind the rapid growth of the cloud industry and market in some developing economies. For instance, in Brazil, e-commerce firms, especially those exhibiting big seasonal variations in demands, have been among the early adopters of the cloud.[11] In India, companies such as MakeMyTrip.com, Flipkart.com, and Bookmyshow.com are using BD and the cloud to provide e-commerce offerings to benefit from the country's rapidly expanding e-commerce market.[12] For instance, Flipkart is reported to analyze twenty-five million rows of inventory data every day in order to make data-driven decisions. BD tools are reported to help e-commerce companies such as Snapdeal and HomeShop18 to generate 30–40 percent of their orders.[13]

The rapid diffusion of cloud-based e-commerce activities in developing economies are also associated with and facilitated by global CSPs' entry into these economies. Firms in these economies are using e-commerce apps developed by global CSPs such as Google, Microsoft, Amazon, and Dell. For instance, the Indian online store Flipkart's cloud infrastructure is built on Dell PowerEdge

servers.[14] Another Indian retailer, Zovi, uses cloud apps of Google, AWS, and GitHub. Likewise, as of September 2014, over 2,000 Chinese e-commerce companies, including Lefeng.com (cosmetics retailer) and Xiu.com (a fashion e-commerce site), were reported to be using Microsoft's Azure platform.[15]

Regarding established foreign CSPs' entry in developing economies, it is worth noting that they offer more sophisticated applications and services compared to local CSPs. In order to illustrate this, let's compare AWS and Alibaba's cloud offerings. According to Alibaba's filing with the US SEC for an IPO, its cloud was capable of handling 3.6 million transactions per minute in 2014.[16] On the other hand, Amazon's data storage system reportedly handled 1.5 million requests per second in 2013.[17] Likewise, as of August 2014, whereas Alibaba had only three BD centers in China and a smaller one in Hong Kong, AWS had twenty-five big and fifty-two smaller data centers worldwide.[18] Local CSPs such as Alibaba, on the other hand, are more effective in providing cloud-based solutions suitable for local needs.

This chapter assesses the roles of BD and the cloud in stimulating the e-commerce markets in developing economies and their potential in overcoming various e-commerce barriers in developing economies. Specifically, we focus on BD and the cloud's roles in overcoming economic, socio-political, and cognitive barriers, which are identified as key hurdles in firms' and consumers' e-commerce adoption in developing economies.[19] Following the OECD, we define an e-commerce transaction as the sale or purchase of products over the Internet or broad computer mediated networks.

6.2 Some Examples of BD- and Cloud-Based E-Commerce Applications Deployed in Developing Economies

6.2.1 The Demand Side: Users of BD- and Cloud-Based E-Commerce Solutions

Key features of the cloud have made it an attractive choice for offering e-commerce solutions by domestic and foreign companies to serve the developing economies. Zovi, a Bangalore India-based e-retailer, uses Google's cloud application for communication and document storage and AWS for application (e.g., relationship-marketing software, chat, email, browsing, e-banking, security applications) and analytics (e.g., tools that allow the company to personalize services and product recommendations). For codes that drive the platform/storefront, it uses the free open source hosting platform GitHub.[20] The company's Chief Technology Officer (CTO) noted that it made more sense financially and operationally to invest resources on the core business of software development rather than on hardware infrastructure and required maintenance. He further noted that AWS deployment helped the company avoid spending US$1 million in initial capital expenses for hardware. The company also reportedly

saved US$200,000 on annual operating expenses. Thanks to the cloud's scalability, the company was able to deal with the increase in visitors from 50 to 100,000 per day without any intervention by the company.[21]

Snapdeal has placed the entire IT infrastructure on the cloud which include storage, web accelerator (proxy server to reduces time to access a website), and firewall components. It extensively utilizes SaaS solutions. It uses Google AdWords for tweeting catalogues and listings, contextual advertising, customer loyalty programs, and roll out campaigns.

Likewise, Bajaj Finserv's auto loans business has adopted SaaS, which has led to better and faster decision-making. During the Diwali festival season, it processes about 50,000 loans a day, which is ten times more than that could be handled by its regular capacity. Bajaj's portal architecture, the main customer-facing interface dealing with over 410,000 customers, is entirely SaaS-driven. Its core data warehousing is on the cloud SQL Server, which is a relational database system. Bajaj Finserv's adoption of Salesforce.com's offering led to an increase of loan applications from 1,500 to a peak of 8,500 per day during the festival season. The ability to send out SMS directly from Salesforce.com to dealers to communicate loan approval is reported to have had a significant impact on loan turnaround times. It helped fulfill its ultimate goal in marketing the personal loan as a viable alternative to the credit card.[22]

Foreign multinationals operating in developing economies have also used the cloud to offer their products online. In 2012, the French cosmetics company Clarins launched an e-commerce site in Demandware. Before that the company had sold its products through other outlets. According to Laurent Malaveille, executive vice-president for global digital, CRM and e-commerce, a cloud-based e-commerce platform can effectively outsource the system's day-to-day technical operations. The company's e-commerce group got more time to focus on key features such as the loyalty program that are linked to the company's success in online sales. The company reported a double-digit sales growth on its Chinese site in the first six months after the launch.[23] As of early 2014, Clarins had twelve e-commerce sites worldwide. Each site is customized for local tastes and runs on an SaaS e-commerce platform. Clarins could move quickly into many international markets without the necessity of adding IT staff to handle the expansion. Another advantage of the cloud is that it can handle the traffic surges during holidays and promotions more effectively. The SaaS route also enabled the delivery of upgrades and new features automatically.

6.2.2 The Supply Side: Providers of BD- and Cloud-Based E-Commerce Solutions and Infrastructures in Developing Economies

As mentioned earlier, global CSPs' entry has been a key factor in stimulating cloud-based e-commerce in developing economies. Microsoft's Azure platform

was launched in China in March 2014 with data centers in Beijing and Shanghai. By September 2014, it was reported to have 9,000 clients, 20 percent of which were e-commerce companies.[24] They included Lefeng.com (cosmetics retailer), Xiu.com (a fashion e-commerce site, which ranked #54 in the *Internet Retailer China 500*,[25] with 2013 online sales of US$180 million), and Cogobuy.com (a B2B site). Xiu.com reported that Azure helped it handle the spike in traffic triggered by an online sales event, which increased the sales by 500 percent. Xiu.com's technology director put the issue this way:

> During peak business days, our site may be hard to access for online shoppers. Without the cloud service we would have to spend lots of money and time to install new servers, and many of them would be idle for normal days when we don't have sales. Azure helps us save the cost of buying servers, and expands our site access capability only when we need it.[26]

As a further example, Brazil's e-commerce website platform Shop Delivery, which allows businesses to create and run their own online store, uses Microsoft's Azure.[27]

Canada's Shopify offers cloud-based POS software for brick-and-mortar retailers (e.g., a cash register to input products, tally costs, and conduct financial transactions, communicate with inventory levels, etc.) as well as to e-retailers. For e-retailers, it offers site templates that can be customized, integrated shopping carts, search engine optimization (SEO) feature, email marketing, inventory management, and analytics. Users also gain from m-Commerce shopping cart, payment gateways to authorize credit card payments, and social media integration. In July 2013, Shopify teamed up with Singapore's SingTel to offer e-commerce solutions in Asia. Shopify started offering localized e-commerce solutions in India, Indonesia, and Malaysia.[28] About 1,000 new stores were created in the last week of August 2013 on Shopify in India.[29]

GS-based technology companies are evolving rapidly and are playing key roles in the development of BD- and cloud-based e-commerce. Alibaba, which is now the world's largest e-commerce company, is among the most high profile companies in developing economies with significant operations in cloud-based e-commerce activities. It has been taking a number of initiatives to become a one-stop shop for SMEs conducting business online. It provides services such as online marketplaces, back-end e-commerce merchant services and its own cloud-computing e-commerce platform.[30] As of September 2014, its e-commerce platform offered traditional features such as online storefronts and an order management system. The company is planning to augment the depth of its offerings by expanding features to support online merchants. In August 2014, AliCloud introduced a data mining and analytics product known as Open Data Processing Service (ODPS), which provides e-retailers with analytical data

about website activities. The users of the service are required to pay about US$100 per month.[31] When merchants enter sales data, the ODPS algorithm scans them and provides predictions for indicators such as future sales and the products that are likely to be in high demand in the next period.[32]

Alibaba's cloud computing business unit has also launched Aliyun Search, which will help users to research various brands and products in order to make buying decisions.[33] Alibaba's cloud unit also specializes in data management which involves e-commerce data mining and processing to customization. Suggestions from Aliyun Search are reportedly based on buying behavior and the results are presented based on an e-commerce point of view. Experts say that Alibaba is in the best competitive position to develop an e-commerce-oriented search engine since it can combine Yahoo's search algorithm with purchasing insights from Taobao and ETao.[34] Note that Alibaba's Taobao is China's largest e-commerce platform and ETao is a comparison shopping engine, which reportedly had over a billion product listings and more than 5,000 B2C and group buying websites.[35] The cloud-based app, Alipay Wallet, allows users to link Alipay accounts to local bank accounts. Users can also transfer money into it from a prepaid account. In this way, it facilitates online payment services in e-commerce.[36] In August 2014, Alipay Wallet announced that it had released more than sixty new APIs for third-party developers in order to build online storefronts.[37] This means that online storefronts can integrate Alipay's underlying programming functions into their applications, which is expected to make it easier and faster for the merchants to develop Alipay Wallet virtual storefronts. Alipay started recruiting merchants for its wallet app in June 2014. In two months, it recruited over 1,000 merchants.[38] Retailers who set up in-app storefronts can sell and market products to Alipay Wallet users and gain access to data analytic tools that allow them to personalize product recommendations.[39]

Another visible Chinese e-commerce company is JD.com. It uses BD to keep inventories low and speed up delivery. It also employs sophisticated BD-based models to run financing for customers.[40] JD.com has formed a partnership with Tencent to integrate e-commerce into the WeChat app. Based on what a user is buying and searching at JD.com, Tencent can send coupons in real-time.[41]

JD.com has also made heavy investments in the IoT. Its 3 System Fridge has sensors on every shelf and an internal camera. It registers the time and date when food items are stored inside. The data is fed to a smart screen on the fridge's front side, which alerts when an expiry date is coming close. It can also order the next grocery list from JD.com based on the fridge's contents.[42] As of mid-2016, JD.com was working with the Joy Link platform, which connects a 3 System Fridge with the consumer's digital devices. The internal camera can be accessed from a smart device's app. A consumer thus can check the fridge's contents even when they are away from home and order groceries. The smart screen on the front also provides opportunities for advertising for e-marketers.[43]

The Delhi-based customer segmentation and marketing automation platform Betaout offers an SaaS-based offering for e-commerce companies. It provides real-time data and machine learning to segment customers, which can help e-commerce companies retain customers, increase conversions, and personalise user engagement.[44]

Another example of an e-commerce solution developed in developing economies is uAfrica.com.[45] It provides a platform to build a cloud-based e-commerce site (uShop.co.za). Its initial offerings included basic online storefront services. The company plans to expand to additional services related to payments, logistics, and marketing supports and then to a multi-channel selling solution. An important feature of uAfrica.com's basic product offering is the ability to trade via mobile devices.[46] As another example, in 2014, Nigeria's Delivery Science launched an SaaS-based model which provides automated proof-of-delivery, intelligent transportation management, and inventory management to facilitate firms' e-commerce activities.[47] Delivery science's BD applications help e-commerce and logistics businesses track and manage deliveries. Its proof-of-deliver product has been updated to integrate services such as simple transport management, point-of-sale, and inventory management and allocation products.[48]

India's Wipro offers cloud-based e-commerce solutions, including omni-channel B2B & B2C e-commerce, platform transformations, and marketplace implementation.[49] Note that an omni-channel strategy involves supporting all channels with a holistic view of customer experience. Omni-channel interactions are integrated and connected, and aim to provide rich customer experiences across devices, channels, time, and context.[50]

6.3 Barriers to E-Commerce in Developing Economies

As noted earlier, prior research has identified e-commerce barriers in terms of three forms of negative feedback systems: economic, socio-political, and cognitive.[51]

6.3.1 Economic Barriers

GS-based firms face a number of economic barriers, such as the high costs of ICT infrastructure, equipment, and operation and the lack of purchasing power. Prior research suggests that firms which use technologies that are more web-compatible and with a higher number and variety of web functionalities (e.g., presentation of contents, capture of transactions securely, and personalization, etc.) are more likely to adopt e-commerce.[52] A larger proportion of firms in developing economies than in more industrialized countries lack such technologies.

The unavailability of credit cards is another major hurdle. This has been a major barrier since as of 2013, only 3 percent of the Sub-Saharan African

population had credit cards.[53] In Africa, the lack of viable payment systems is considered to be a bigger hurdle than the lack of connectivity.[54] There are also problems associated with the lack of economies of scale in small developing countries.[55] Slow Internet diffusion in developing countries can be attributed to market and infrastructural factors controlling the availability of ICTs. A large proportion of the population in many developing economies also lacks the basic prerequisites to Internet use. In Tanzania and other countries, for instance, a lack of electrical supply and a low teledensity have resulted in a low Internet usage in rural areas.[56] Consequently firms in developing economies, especially SMEs, exhibit a very low level of adoption of the Internet and e-commerce. For instance, in India, as of 2013, only about 5 percent of SMEs were reported to be using a digital platform.[57]

Due to the above barriers e-commerce provides, in developing economies they are exploring alternative business models.[58] A large proportion of e-commerce in Asian economies such as China, Indonesia, and India takes place on a cash on delivery (CoD) basis.[59] The CoD system, however, has some major drawbacks, especially from the businesses' perspective. In Indonesia, for instance, it is a common practice for customers to cancel their purchases after the products are delivered. In other cases, customers order more than one unit of the same product (e.g., in different sizes, and colors), then choose the one they like after the products are delivered.[60]

6.3.2 Socio-Political Barriers

Socio-political barriers can be explained in terms of formal and informal institutions.[61] They often tend to be more difficult and time-consuming to overcome than technological barriers.[62] The literature provides abundant evidence that legal barriers are among major hindrances to e-commerce in the developing world. A survey conducted among Brazilian consumers indicated that the low e-commerce adoption rate was related to government regulations such as concern about privacy and security, lack of business laws for e-commerce, inadequate legal protection for Internet purchases, and concern over Internet taxation.[63] Likewise, in China, the lack of institutional trust due to the weak rule of laws was a major barrier to e-commerce.[64]

6.3.3 Cognitive Barriers

Cognitive factors are related to mental maps of individuals and organizational decision makers.[65] Some analysts argue that cognitive barriers are more serious than other categories of barriers in developing countries.[66] Many effects such as inadequate awareness, knowledge, skills, and confidence serve as cognitive feedbacks. In developing countries, organizations' human, business, and technological resources, a lack of awareness and understanding of potential opportunities,

risk aversion, and inertia often lead to a negative cognitive assessment of e-commerce.[67] Businesses are also concerned about handling demands during peak-load periods. A final consideration with cognitive barriers is related to general and computer illiteracy and a lack of English language skills.[68]

6.4 BD and the Cloud's Potential to Overcome the Barriers to E-Commerce

Table 6.1 presents the cloud's role in overcoming various barriers to e-commerce in developing economies. The table also gives some perspective to the barriers that are not overcome by the cloud or new barriers that have emerged in the cloud environment.

6.4.1 The Roles of BD and the Cloud in Overcoming Economic Barriers

The main attractiveness of the cloud is that it leads to a reduction in upfront investments and addresses constraints related to organizations' human, business, and technological resources. For instance, India's Apeejay Stya and Svran Group, which is a US$1 billion plus conglomerate, moved the entire IT functions including the mission-critical ones to AWS. The company reported that by doing so, it reduced IT staff from twenty-three to three and cut costs by over 80 percent.[69]

As noted above, market and infrastructural factors controlling the availability of ICTs and a lack of purchasing power act as key barriers in developing economies. To address the low purchasing power, local and foreign CSPs are offering e-commerce solutions at low prices. In August 2014, the head of AWS in India noted that the company had lowered prices forty-five times since 2006.[70] Offerings by local and foreign companies are bundled as solutions to facilitate the use of the cloud for e-commerce. In India, for instance, Airtel's data solutions (DSL, the premium Internet offering Internet Leased Port [ILP], 3G and 4G) are bundled with Shopify's cloud-based solutions. The bundled offerings provide the features needed for SMEs' e-commerce deployment.[71]

A large number of firms and individuals in developing economies tend to use technologies that lack web compatibilities and have a limited number and variety of web functionalities. For instance, it is not possible to use low-end mobile phones to perform most e-commerce activities. In this regard, note that in 2011, India had more than 700 million mobile phone users, which was about forty times the number of Internet users in the country. Over 50 percent of these phones had only voice and text messaging capabilities. Technology companies have come up with innovative solutions in order to overcome obstacles associated with accessing the cloud-based applications with technologies with limited functionalities such as low-end mobile phones. To take one example, to

cater to the needs of low-end mobile phone users, Hewlett-Packard has developed cloud-based SiteOnMobile to deliver Internet experience over low-end phones.[72]

Many SMEs in India that have invested in e-commerce websites but they have not been able to benefit from them. SiteOnMobile enables them to define specific tasks on their websites. One example of a task could be "Buy Solar Stoves." SiteOnMobile makes those tasks accessible to their customers from mobile phones. For this purpose, HP introduced the concept of "Tasklets," which are special types of "task-based widgets" that can be created by a user by "showing the action once on the browser."[73] For the first time, the user performs the tasks on multiple websites using HP's special browser. SiteOnMobile then automatically generates a widget-like interaction for that task for the user. Let us assume that a user has created a tasklet of "Book a Taxi." In order to book a taxi, the user does not have go through several webpages to reach the booking page. SiteOnMobile will perform all the steps for the user for subsequent uses once the interactions are created in HP's special browser. The tasklets can be accessed by users via SMS or voice services. SiteOnMobile performs all the needed tasks on the cloud and sends back the result to the user over SMS. For example, if an SMS "Book a Taxi" is sent to a predefined SMS access code, a taxi will be booked and the user will receive back details about the taxi that has been booked.[74]

Regarding the barriers associated with a low penetration of mainstream online payment methods such as credit cards, it was reported that foreign CSPs require cloud users to pay with credit cards. Among the encouraging developments is the emergence of local CSPs, which sell to non-credit card users. In Africa, for instance, CSPs accept payments by the mobile payment system, MPesa. Likewise, given the unavailability of mainstream payment methods such as credit cards and the risks of existing mechanisms such as CoD, cloud-based payment mechanisms such as Alipay possess a high degree of attractiveness and utility. Alipay Wallet's features include payments at brick-and-mortar stores, transportation booking, and appointment booking at hospitals. Merchants can also offer discounts, coupons, and special membership privileges to Alipay Wallet users.[75] Users of Alipay can also make e-payments at brick-and-mortar shops.[76] In June 2014, the Chinese online grocery store Yihaodian, which is majority-owned by WalMart, launched a store front on Alipay Wallet. It allowed customers to buy groceries from their Alipay Wallet app.[77]

6.4.2 The Roles of BD and the Cloud in Overcoming Socio-Political Barriers

The cloud's transformative potential has resulted in significant national political decisions to utilize this technology for key economic activities. To some extent, such decisions addressed issues such as the lack of appropriate government

regulations related to privacy and security, and the lack of institutional trust. For instance, Brazil's federal representative Ruy Carneiro presented a bill for the creation of a cloud computing framework and the introduction of data protection laws. The bill is intended to address the lack of regulations around data privacy protection. It also addresses interoperability and standards for services provision.[78] Likewise, India's industry body, National Association of Software and Services Companies, has issued best practice security standards, procedures, and guidelines for its member companies. However, compliance is voluntary.

6.4.3 The Roles of BD and the Cloud in Overcoming Cognitive Barriers

Unlike client-based computing, cloud-based software is easier to install, maintain, and update.[79] For instance, in the above examples, Demandware makes new features available to Clarins on a rolling basis. Thus in order to expand e-commerce activities, Clarins is not required to undergo any major upgrade project or add staff for maintenance.[80]

The cloud's key features such as ability to reduce upfront investments and handle business processes and transaction without the intervention of an organization have greatly increased the confidence of firms in developing economies. According to a survey conducted by Vmware and Forrester in 2012, 80 percent of respondents in India believed that the cloud would help reduce IT costs, and 82 percent believed that it will help optimize IT management and automation capabilities.[81]

Measures taken by global CSPs have also helped overcome cognitive barriers associated with e-commerce adoption. Global CSPs such as Amazon and Google hold seminars for start-ups in India, Indonesia, and many other developing economies.[82] There are also consultants, who teach businesses how to use the clouds of Amazon and other CSPs. In addition, Google has teamed up with Endurance International Group to help African and Southeast Asian SMEs to launch online businesses. Endurance helps SMEs set up Google My Business, which is a free service and helps customers find a business online. SMEs can pay for add-ons such as the creation of a full-blown website and launch of e-commerce.[83] In this way, firms' e-commerce adoption constitutes a gradual process instead of a quick change.

6.4.4 Barriers That Still Remain and New Barriers That Have Emerged in the BD and Cloud Environment

Obviously, it is not possible for BD and the cloud to overcome all the barriers facing developing economies. These economies still face severe market and infrastructure constraints. Most cloud services, for instance, rely on bandwidth,

TABLE 6.1 The Roles of Big Data and the Cloud in Overcoming the Barriers to E-Commerce

Barrier	*Barriers Overcome by BD and the Cloud*	*Barriers That Still Remain and New Barriers That Have Emerged in the BD/Cloud Environment*
Economic	• Innovative solutions to overcome obstacles associated with accessing the cloud-based applications with low-end mobile phones (e.g., SiteOnMobile). • CSPs are offering e-commerce solutions at low prices. • Offerings by local and foreign companies are bundled. • Local payment solutions such as MPesa and Alipay.	• Lack of bandwidth • Lack of electricity • Lack of local data centers • Limited Internet and PC use
Sociopolitical	• Introduction of data protection laws (e.g., Brazil). • Trade associations' roles: India's NASSCOM's best practice security standards, procedures, guidelines.	• Local data center requirement and other protectionist measures in the cloud sector (e.g., in Brazil, China and India).
Cognitive	• Cloud-based solutions are easier to install, maintain, and update. • Ability to reduce up-front investments and handle business processes and transaction: increased the confidence. • Measures taken by global CSPs to create cloud awareness (e.g., Google's seminars for start-ups).	• Concern about the loss of control in the cloud model: Unwillingness to outsource. • Reduction in control over customer experience. • Concerns related to data security.

which is the most glaring shortcoming of most developing countries, especially in the rural areas. Likewise, the cloud is not of much use to firms who lack access to basic needs such as electricity.

Cloud-based e-commerce solutions in these economies are provided using cloud servers located at distant data centers in foreign countries. For instance, India's nationwide cab-booking service Getmecab uses Amazon servers. The closest servers are in Singapore.[84] Likewise, India's Tata Communications opened a data center in Singapore to offer cloud services to foreign clients due to Singapore's cutting-edge IT infrastructure, the availability of IT experts, and government incentives.[85] Due primarily to poor bandwidth in India, Tata Communications decided to locate the facility in Singapore, despite Singapore's expensive land and high temperatures, which increase the costs of keeping the servers cool. As of 2014, India's national 3G coverage in India was 9 percent. In those cities where 3G coverage is available, the services perform poorly due to congestion.[86]

Many governments have viewed the cloud as a disruptive technology with the potential to change the national competitive performance. They are also preoccupied with national security concerns regarding the sensitive data and information stored in the cloud. Consequently many governments in developing economies have pursued a somewhat protectionist agenda regarding the development of the cloud industry and market. These barriers are especially problematic for global efficiency because technologies such as cloud are cross-border in nature.[87]

The Indian government proposed a measure which requires companies operating in the country to locate part of their IT infrastructure in the country. This requirement was for providing law enforcement agencies ready access to encrypted data on servers in India. This measure also prohibits businesses to move data related to Indian citizens and government organizations out of the country. Failure to comply will be a criminal offence and responsible people will face prosecution.[88] The guidelines of the central bank, the Reserve Bank of India (RBI), prohibit storing customer data outside India, which limits cloud adoption by financial services companies.[89]

Similarly, due to concerns related to national security, currency control, and industrial policy, China has local data server requirements.[90] The Chinese government has also expressed a desire to see the cloud industry dominated by local companies. In addition, it wants Chinese companies to control a higher share of world cloud markets. To fulfill this desire, it has taken a number of measures. According to the NDRC, the government has viewed cloud computing as a strategic industry.[91] It is worth noting that companies in other strategic sectors are eligible for market protection. China has classified cloud computing as a value-added telecom service (VATS). Under the Chinese regulatory regime, and in accordance with China's WTO commitments, foreign-company ownership is capped at 50 percent in VATS ventures and 49 percent for basic telecom

services.[92] This means that foreign CSPs are required to find local partners in order to operate in China. While the central government defines cloud computing as a value-added service, there is no specific "cloud computing" category in the license list of value-added services. To deploy its Microsoft Office 365 in China, it is hosted by a Chinese domestic company by license requirement. Other foreign cloud providers such as Amazon, IBM, and SAP have followed similar models.[93]

In the same vein, in September 2013, the then Brazilian President Rousseff asked the Congress to introduce regulations to require foreign companies to store data generated by Brazilians on local servers.[94] Among foreign ICT companies, there is widespread and growing disenchantment with the adequacy of the Brazilian regulatory system for the cloud industry. In the 2012 ranking of the Business Software Alliance of twenty-four countries, in terms of the cloud environment, Brazil finished last. In the 2013 BSA Global Cloud Computing Scorecard, Brazil improved slightly and ranked twenty-second of the twenty-four economies considered.[95] The scorecard considered Data Privacy, Security, Cybercrime, Intellectual Property Rights, Support for Industry-Led Standards, and International Harmonization of Rules Promoting Free Trade and ICT Readiness, Broadband Deployment. Brazil was among the countries showing the most improvement in their infrastructure score for 2013. Brazil also lacks an appropriate framework for the development of ICT standards, and gives domestic service providers preferential treatment in public procurement.[96]

Regarding the cognitive institutions, the cloud involves outsourcing IT functions. Some organizations hold the view that the adoption of the cloud model would result in the loss of control. For instance, China's state-owned enterprises (SOEs) exhibit a higher level of concern regarding data security: they have a tendency to distrust CSPs and are reluctant to outsource IT needs and move to the cloud.[97] Indeed, until not long ago, SOEs were not allowed to use outsourced data center services.[98] There also have been concerns related to data security, which has made businesses cautious in spending on cloud services. A further limitation of cloud-based e-commerce solutions concerns the reduction in control over customer experience.[99]

6.5 Discussion and Concluding Comments

While some of the barriers to e-commerce highlighted above could be mitigated through the use of clouds (e.g., the lack of human, business, and technological resources, the low level of computer illiteracy, etc.), other barriers (e.g., the lack of credit card, the lack of awareness and understanding of potential e-commerce opportunities), require broader efforts to overcome. Some socio-political measures (e.g., by the Brazilian government and India's NASSCOM) taken to facilitate the development of the cloud industry and market are likely to have positive effects on e-commerce. Nonetheless, other sets of measures

taken by national governments to protect economic and national security concerns, which are associated with the cloud's radical and disruptive nature, are likely to have adverse effects on the healthy competition and may limit the choices available to businesses. Buyers and sellers are thus likely to face different types of socio-political barriers to engage in e-commerce activities. Reduction in control over customer experience and concerns regarding security in the cloud should also be taken into account to assess the potential of cloud-based e-commerce solutions.

Overall, the cloud has increased the confidence and capability, and improved the competence of firms in developing economies, especially of SMEs, to engage in e-commerce activities. Cloud-based e-commerce infrastructures and applications as well as retail solutions such as POS systems are less expensive, which is especially important for SMEs. Another key benefit is that thanks to the cloud, businesses are less concerned about fulfilling demands during the peak data flow periods.

The experiences of economies such as China and India indicate that cloud-based e-commerce solutions provided by local and global CSPs have enriched the e-commerce ecosystems of these economies. These CSPs' cloud offerings have increased the breadth and depth of e-commerce offerings and have made it convenient and attractive for both buyers and sellers to engage in e-commerce activities. In a further attempt to improve the ease with which firms can adopt cloud-based e-commerce, offerings by local and foreign companies are being bundled as solutions.

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PART III

Case Studies of Diffusion and Impact of BD and Cloud Computing in Major Economies in the Global South

7

SUB-SAHARAN AFRICA

7.1 Introduction

BD and the cloud have become increasingly pervasive in SSA economies. According to the undersea cable operator, MainOne, the African cloud market was US$35.6 billion in 2015.[1] The market research company, IDC estimated that South African cloud services market reached US$230 million in 2014.[2]

According to IBM, as of 2014, about half of the medium and large businesses in South Africa and Kenya had adopted the cloud.[3] A survey of World Wide Worx and Cisco revealed that 44 percent of Nigerian businesses had plans to adopt the cloud in 2014. Another study found that at least 40 percent of businesses in Nigeria and Kenya were in the planning stages of BD projects in 2015.[4]

Some economic sectors are more advanced than others in the adoption of BD analytics and the cloud. For instance, SSA-based firms in retail, telecoms, oil and gas, and banking are most likely to use the cloud to handle large volumes of data transactions.[5] To take an example, in Nigeria and Angola, the oil industry has driven the investment in data centers. This industry exhibits a high degree of orientation towards the global market.[6]

Most SSA economies in the past needed to rely on satellite for Internet connection. Satellite-based connections are expensive. Moreover signals often need to take a 76,000 km round-trip to and from orbits. The resulting delays are especially disruptive and troubling for data-intensive applications or banking transactions.[7] In this regard, an important factor is that undersea cables have landed in some of these economies. Due to this, data centers are growing rapidly in Kenya and other countries.[8]

Competitively priced fast and ultra-fast internet access is becoming widely available in SSA economies. The region's telecom companies are using this as a

selling point to attract customers. For instance, Liquid's ads in Zambia and Zimbabwe say that it takes a shorter time to download a movie than to prepare popcorn by microwave.[9]

Major challenges and barriers to the BD and the cloud pathways include the lack of local infrastructures, unaffordability, and relatively narrow local offerings. For instance, according to Seacom, in 2014, 90 percent of African internet content was hosted outside the continent. The resulting latency has a visible effect on video streaming and other bandwidth consuming applications. Such services and applications also cost more on the continent.[10]

7.2 The Current State of BD and Cloud Market

A number of creative BD- and cloud-based apps have been developed that are unique to SSA economies.

7.2.1 Education

The Higher Education Alliance for Leadership through Health, a consortium of seven universities (in Kenya, Ethiopia, the Democratic Republic of Congo, Tanzania, and Uganda), works with industry experts to extend education through virtual labs that students access remotely.

South Africa's Center for Higher Education Transformation lets African universities access and manipulate its performance data stored on a Google platform.[11] Also, Google has provided its cloud-based Apps for Education to universities in Rwanda, Kenya, and Mauritius.

In 2009, Microsoft donated 250,000 laptops to teachers in Ethiopia. The software in the laptop is managed by the US company FullArmor through Microsoft's Azure cloud platform.[12] Teachers can download curriculum; maintain, view, and track academic records; and transfer student data securely.[13]

7.2.2 Health Care

As explained in Chapter 1, in South Africa, the Mothers-2-Mothers (M2M) program combines the cloud with database technology and mobile services to fight HIV/AIDS transmission from mother to children. M2M digitizes patient records and shares them with counselors across its networks of over 700 sites in Africa. The records contain information on treatment plans and advanced reporting tools, which allow quick response. As of 2011, M2M had served more than 1.5 million women in nine Sub-Saharan African countries.

In Nigeria and Ghana, a cloud-based app is used to identify fake prescription drugs. When buying a drug, a customer can find a twelve-digit code by scratching a sticker on the package and can then send a text message to a number. The code is matched with that registered by the pharmaceutical company in HP's

cloud database. The customer receives a response back that tells whether the drug is counterfeit.

Scientists hope that it is possible to use BD to dramatically reduce and even eliminate some diseases such as malaria. For instance, in Namibia, satellite imagery is being used to map environmental conditions that can help malaria parasites and mosquitos to grow. For instance, factors such as vegetation density, population, and rainfall which are found to affect mosquito and parasite populations and the rate of transmission are tracked. This information is combined with the movement pattern of malaria-infected people. Anonymized cellphone records of over two million users provided by Namibia's largest network provider, Mobile Telecommunications Limited (MTC), was used to study travel patterns. This information allowed interventions such as indoor spraying with insecticide to disrupt the malaria transmission cycle. For instance, in 2013, Namibia's Ministry of Health used the information to target bed net distribution and indoor insecticide spraying to areas with urgent needs. The limited resources were used to reach 80,000 people that were most likely to be affected by the malaria transmission cycle.[14]

7.2.3 Farming and Agriculture

Improving agricultural productivity is likely to be among the most positive effects of BD in SSA economies. It is estimated that the average African smallholder farmer produces only a quarter to half of the productive potential. BD can help them make full use of their productive potential. BD can also help farmers reduce costs by providing access to detailed information about irrigation and reduce wastage in resources.[15]

A number of efforts and initiatives are being undertaken to digitize SSA's agricultural activities. A promising area of BD and cloud utilization to increase agriculture productivity is soil infrared spectroscopy. Data about soil characteristics such as texture, organic matter, and fertility help determine fertilizer needs and can be used as a basis for precise prescriptions. One way to get information about soil characteristics is to use orbiting satellites, which can collect data in a cost-effective manner by measuring electromagnetic radiation reflected from farmlands.[16] Efforts have been made to develop national and regional databases for soil properties. In 2009, Nairobi, Kenya-based World Agroforestry Centre started cataloguing the radiation signature of about 100,000 samples of African soils. It also announced a plan to give the information to Colombia-based International Centre for Tropical Agriculture in order to build a database, known as the Digital Soil Map. The goal of the project was to combine the information with regularly updated satellite imagery of farmland in forty-two African countries in order to provide farmers with free forecasts.[17] The Africa Soil Information Service (AfSIS) has developed a soil infrared spectroscopy technique to predict the characteristics of a soil sample based on the light reflected by the

sample. A test costs only US$1 to the farmer. AfSIS has also launched a soil properties map of Africa at a 250 m × 250 m resolution. AfSIS was reported to be helping SSA economies such as Ethiopia, Ghana, Nigeria, and Tanzania to establish national soil information systems and services, which are based on soil spectroscopy and digital soil-mapping technology.[18]

At a country level, Ethiopia's Agricultural Transformation Agency is reported to be developing the Ethiopian Soil Information System (EthioSIS), which is a digital soil map analyzing the country's soils down to a resolution of 10 km x 10 km. In 2014, the Agency launched an agricultural hot line. By the end of 2015, it had received about 6.5 million calls. It sends text messages and automated calls related to up-to-date information to 500,000 users. A combination of the two systems is likely to provide highly customized information to farmers.[19]

Green Dreams' iCow helps farmers track and manage cows' fertility cycles. It informs them about important days of cow gestation periods, collects and stores milk and breeding records, and finds the nearest veterinarian and other service providers. A simple system involving Google Docs is also used. If Green Dreams and the vet can't answer a question, the question is uploaded to the iCow system and vets send messages among themselves to come up with the best answer, which is then forwarded to the farmer. As of 2012, 42,000 farmers were using iCow, which increased milk production by 2–3 liters per cow per day.[20]

A National Geographic article reported the story of a Farmer Thuo, who experienced substantial increase in his yields and improvement of his animals' health thanks to the adoption of iCow. By applying the knowledge (e.g., fodder production, hygiene, and animal diseases) that he received from iCow, he was able to double the production of milk from his cows. The iCow system also helped him manage challenges such as food shortages that he had faced in the past. Before he started using iCow, Thuo lacked the knowledge and skills required to measure the cost per liter of milk. He started keeping records of his farming activities. Thanks to the confidence that iCow gave him as a farmer and a businessman, he was considering to expand into pig farming.[21]

7.2.4 E-Business and E-Commerce

Cheki runs a cloud-based used-car classified business in numerous African countries, including Kenya, Nigeria, Malawi, and Ghana. As of 2012, it served 1 million people and its website had approximately one billion page views per month.

In addition, Nigeria's largest jobs and careers website, Jobberman, runs on Amazon Web Services (AWS). South Africa's luxury goods company, 36Boutiques, has also deployed AWS.

In July 2015, Nedbank became the first South African bank to offer a data analytics tool, Market Edge, which records customers' shopping behavior.[22] The

tool offers behavioral insights mined through BD on a platform that provides information about customers' spending patterns, income segmentation, gender, and age demographics. Businesses can look at consumers' transaction histories, which can be used to improve product development, and maximize engagement, conversions, and loyalty. Market Edge can be used by Nedbank's card-accepting businesses.[23]

7.2.5 Business Process and IT Outsourcing

South Africa's call center agents and software developers are increasingly leaving dedicated facilities and embracing cloud-based systems, boosting productivity by 20 percent. Because they don't need to own and maintain equipment and can log in from anywhere using IP lines, they have lowered their capital investments.[24]

7.2.6 Banking and Finance

In South Africa, Nedbank has automated business processes through the cloud, and MTN offers SaaS applications for micro-finance institutions. Also, in 2011, Kenya's Safaricom launched Safaricom Cloud and started hosting the Mpesa mobile money service locally.[25] Furthermore, in early 2013, the Commercial Bank of Africa signed a cloud infrastructure deal with HP to increase its storage capacity by 50 terabytes.

Nigeria's consumer finance company One Credit uses a cloud-based core banking platform developed by Berlin-based Mambu in order to expand access to credit for the unbanked population. One Credit has also partnered with retailers to provide point-of-sale financing to buy consumer goods and household appliances.[26] Loans in the N50,000–500,000 (about US$300–3,000) range are provided for a six-month period. The loans are provided within twenty-four hours of document verification and do not require collateral, salary account, guarantors, or deposit.[27]

InVenture Capital Corp uses BD to give loans to customers in SSA economies such as Kenya and Tanzania that do not get credit from traditional banks.[28] It offers loans via smartphones based on more than 10,000 data points per mobile user to determine their credit profile.[29]

Some banks in SSA have expansion strategies that employ branchless banking relying on BD and the cloud. For instance, Ecobank Nigeria's plan is to use the state-of-the-art technologies such as social media, BD analytics, and cloud to increase market penetration instead of building new branches.[30]

7.2.7 Health Care

An analysis of medical data of more than 350,000 African children by researchers of Radboud University Medical Center was carried out to study the effects

of BCG vaccination (against tuberculosis), DTP vaccination (against diphtheria, tetanus and pertussis), and measles vaccination on growth and health of SSA children under five. The analysis indicated that timing of vaccination was among the most important factor. Early vaccination helps to achieve the best health results for children. Findings also indicated possible harmful effects of delayed vaccinations. In some way, the findings challenged the effectiveness of the present vaccination schedules. For instance, whereas the WHO recommends administering BCG vaccine immediately after birth, BCG vaccination is often delayed. WHO also recommends administering the DTP1 vaccine after six weeks and measles vaccine after nine months.[31]

7.2.8 Environmental Monitoring and Protection

One estimate suggested that West African countries lose US$1.3 billion annually due to illegal fishing. Overfishing's impacts also include the reduction of fish stocks and local catches and the adverse impact on the marine environment. Local communities also lose opportunities to catch, process, and trade fish.[32] SSA economies such as Gabon, Guinea Bissau, Mauritius, and Mozambique have ratified the UN Port State Measures Agreement (PSMA), which is the world's first binding international accord targeting Illegal, Unreported and Unregulated (IUU) fishing.[33] The signatories of the PSMA are working on a comprehensive set of measures and instruments including the use of BD to fight IUU fishing. For instance, BD can help identify patterns of suspicious fishing activity by analyzing data from AIS and other sources. Measures are being taken to collect data from seafood processors, distributors, and supply chain management.

An article published in the *Huffington Post* explains that drones are used to track and prevent elephant poaching in Burkina Faso and to prevent rhino poaching in Southern Africa.[34] In 2013, scientists completed an unmanned aerial survey of wildlife in Burkina Faso's Nazinga Game Ranch using drones. Since drones are cheaper and can be launched more easily compared to a plane, they provide tremendous opportunities for SSA economies.[35] Kenya's Ol Pejeta Conservancy has collaborated with San Francisco-based Airware to deploy drone systems to protect rhinos in its 90,000-acre reserve. Rangers at the base operate the drones. Rangers track flight paths and the UAV's point of view through high-definition cameras.[36]

7.3 BD and Cloud Deployment in Modern Versus Traditional Sectors

Table 7.1 compares BD and cloud deployments in traditional versus modern sectors. The case of Nedbank, which uses services provided by IBM, AWS, and others to cope with high demands,[37] reflects the growing market for sophisticated

TABLE 7.1 Cloud Deployment in Traditional and Modern Sectors in SSA Economies: A Comparison of Green Dreams' iCow and Nedbank's E-Banking

	Traditional Sector (iCow App)	*Modern Sector (Nedbank's E-Banking)*
User device	Low-priced/feature cell phones	PC or smartphones
Method for serving users	Text messages	Internet, text messages Use of BD solutions to deliver "right time right place propositions" to customers.
Roles of local cloud providers	Green Dreams envisioned and developed the system	The digital certificates placed on the phone and push notifications were developed by South Africa's Entersect Technologies.
Roles of global cloud providers	It makes limited use of Google Docs	IBM Cognos platform is used for budgeting and forecasting. The system exploits AWS to handle massive amounts of mobile phone calls connecting to its infrastructure.
Bandwidth requirement	Low	High
Importance of security	Low	High

Source: Adapted from N. Kshetri, Cloud Computing in Sub-Saharan Africa, *IEEE IT Professional* (2013) 15(6), November/December, 64–67.

Note

1 Fred Swanepoel and Philip Wessels, *NEDBANK GROUP LIMITED:* Renaissance Capital Banking IT Day, April 14, 2015.

applications. Nedbank teamed up with South Africa's Entersect Technologies to develop a secure system based on digital certificates and push notifications. Users approve or deny transactions on phones by entering PINs.

However, financial institutions such as Nedbank might face fluctuations in demand. For example, the end of the month is a high transaction period, because that's when employees are paid. Likewise, the end of the year and holiday shopping seasons face high demands. The system scales up during high transaction periods and scales down in slower periods.[38]

Compared to the more traditional iCow application, Nedbank's application is more costly. For example, digital certificates must be installed on the phone to authenticate transactions.

7.4 Key Driving Factors of BD and Cloud Industry and Market

The growth of SSA economies' BD and cloud industry and market is driven by a number of factors, which include government initiatives, local entrepreneurial activities, foreign multinationals' entry into the region's cloud sector, improving international bandwidth, international agencies' roles, and philanthropic and charitable causes.

7.4.1 Government Initiatives

Governments in SSA economies are making efforts to strengthen the BD and cloud ecosystem. In May 2016, the government of Rwanda announced its plans to make government data accessible online in order allow interested parties to use them for business, research, education, and other purposes. By doing so, Rwanda will be the fourth East African country after Kenya, Tanzania, and Uganda to have data portals. The National Institute of Statistics will implement the policy.[39]

Rwanda has also a plan to build a US$1.9 billion innovation city in the Kigali Special Economic Zone. The city will comprise key elements of a typical urban center such as corporate buildings, retail, leisure, sports, accommodation, and a healthcare center.[40]

7.4.2 Local Entrepreneurial Activities

Local entrepreneurial activities have helped cloud development. Innovation centers, such as Kenya's iHub, have brought together software developers and entrepreneurs. South Africa's Integr8 and MTN, and Zimbabwe's Twenty Third Century Systems, have launched cloud offerings in Sub-Saharan Africa. MTN MyOffice supports accounting, human resource, CRM, email and video conferencing, storage and back-up for SMEs in manufacturing, hospitality, micro-finance, and advertising.[41]

MTN Nigeria has developed a data center in Lagos with 500 m^2 of collocation and hosting space.[42] MTN offers cloud-based services to SMEs. Likewise, the Nigerian company Computer Warehouse Group (CWG) launched a Tier 3 data center in the country.[43] Note that Tier 3 facilities are often utilized by large businesses, which have 99.982 percent uptime, no longer than 1.6 hours of downtime per year and provide at least seventy-two-hour power outage protection.[44] In 2014, MainOne reportedly completed a US$40 million data center facility in Lagos. In 2014, Rack Centre completed a Tier 3 data center with 3,000 rack spaces.[45]

MTN Nigeria, Globacom, Airtel Nigeria, and Etisalat Nigeria have also invested in data centers. These companies are deploying next-generation networks (NGN) and Business Intelligence (BI) software tools. For instance,

Globacom was reported to spend US$1.25 billion to build an Internet Protocol (IP) network. MTN is reported to spend over US$1 billion annually on its network. Likewise, Airtel and Etisalat spent over US$3 billion to improve their networks in order to make them useful for BD. As data volume expands, telecom operators can mine consumer data to enhance operational efficiency and increase revenue.[46]

In 2011, Safaricom launched the Safaricom Cloud, hosting platforms for government agencies and corporations and other offerings. By 2011, it had invested US$150 million and announced plans to invest another US$200 million.[47] Safaricom teamed up with Cisco (storage), EMC (security), and Seven Seas Technology (overseeing and training).

Safaricom has hired the Netherlands-based BD analytics firm Flytxt to help monetize mobile consumer data. BD analytics would help Safaricom to improve customer experience through personalization and better engagement with customers. As of May 2016, Safaricom had twenty-five million customers in East Africa. Its products included voice, data, mobile money, and enterprise segments.[48]

7.4.3 Improving Bandwidth

Sub-Saharan Africa's international bandwidth has increased dramatically. For instance, during 2011–2015, Africa's bandwidth capacity grew by 51 percent, which was higher than any other world regions.[49] In 2012, Kenya was connected to SEACOM, The East African Marine System (TEAMS), and East African Submarine Cable System (EASSy) cables, and its bandwidth increased from 20 to 53 GBPS from 2010 to 2011. In Nigeria, Glo-1 was launched in 2009, and other cables in 2010 and 2012 broke Nitel's SAT-3/WASC monopoly.

Telecommunications providers have made heavy investment to accelerate the diffusion of fiber Internet in Africa. The first phase of the African Coast to Europe (ACE) submarine communications cable started in 2012. It is a 17,000 km-long fiber optic cable project, which aims to connect twenty-three countries.[50] As of 2015, Mauritius-based Liquid Telecom was estimated to spend about US$500 million in more than 18,000 km of fiber cable in Africa.[51] In July 2015, China's Huawei started work on a 4,000 km fiber optic cable project, which is expected to connect Guinea and other West African countries by 2017. The cable will have seventy-seven exchange points.[52]

All these developments are likely to have a major impact on the use of BD and the cloud in SSA economies. SSA's home-grown data center industry has been growing rapidly. Countries such as South Africa are reported to have some high-quality data centers. The director of the Ugandan Internet eXchange Point noted that while it was more attractive to host SSA-oriented data services in Europe or North America than in Africa in the past, it is becoming increasingly attractive to host the services in Africa.[53]

Nigeria's government agencies and the private sector currently host their data in foreign locations. In May 2016, the country's Communications Technology Minister noted that once the country's data centers develop sufficient capacity to handle data generated in the country, the Federal Government would stop hosting data overseas.[54]

7.4.4 International Agencies

The role of UNESCO and other international agencies deserves mention. In 2006, the World Bank (WB) and the African Development Bank financed a US$280 million cable project serving twenty-three countries. In 2007, the International Finance Corporation invested US$32.5 million in EASSy, connecting twenty-one countries.[55] Likewise, Sierra Leone received US$31 million to connect to ACE cable through the WB-funded West Africa Regional Communications Infrastructure Program.[56] The WB also provided bandwidth subsidies to many universities.[57]

Indirect links also exist through investment in BD companies focusing on the developing world's cloud and BD markets. The IFC has invested in Silicon Valley-based cloud-based software company Ayla, the satellite company Planet Labs, and the online education company Coursera. Planet Labs focuses on satellite imagery and BD in order to learn about the industry and its impact. The investment is then narrowed down to sub-industry or firm level (e.g., a drone service operator from a developing country).[58] The IFC invested US$20 million in Planet Labs in 2015. It is argued that Planet Labs is having an immediate impact on the population at the bottom of the pyramid. Its small satellites gather unique data sets that offer insights such as ways to improve crop management in response to the effects of drought. Planet Labs was reported to have more than fifty Driverless Operated Vehicle Environments (DOVEs) that orbit the earth every ninety minutes taking high-resolution photographs that cover most of the planet each day.[59]

FARM Limited was Planet Labs' first Africa-based customer. FARM aims to "boost sustainability and profitability in agriculture by identifying the inherent risks along the agricultural value chain; and managing them with new technologies, including remote sensing."[60]

7.4.5 Foreign Multinationals' Activities

Foreign multinationals' activities are stimulating the growth of the BD and cloud markets in SSA economies. Google's Project Link aims to bring faster and reliable Internet to Africa. As part of the Project Link, the company launched a metro fiber network in Uganda's capital, Kampala.[61]

In addition to its Johannesburg data center, IBM built its 41st global innovation center in Kenya in 2013. Other global providers, such as HP and VMware,

have a significant presence in Sub-Saharan Africa. Amazon's customer-service center in South Africa opened in 2011 and employs 1,400 people, and in 2012, it launched the AWS Developer Support office in Cape Town.

Specialized providers have also entered Sub-Saharan Africa. In 2012, Switzerland-based Sofgen launched the core banking platform, Temenos T24. It targets banks, micro-finance institutions, and savings and credit cooperatives and has built-in fraud detection capabilities. T24's clients include Kenya's Fountain Credit Services and Uganda's Tropical Bank.[62]

A non-African company that is aggressively pursuing BD and cloud in Africa is China's Huawei Technologies. Huawei Technologies had laid over 50,000 km of fiber optic cables in Africa, which is expected to stimulate its data service business.[63] In April 2016, a high-tech roadshow was launched in Zambia by China's Huawei Technologies with a series of events related to cloud computing and BD.[64] The roadshow's theme was Smart Zambia: Smart Nation. Government employees and industry experts were able to see the developments and learn about BD and cloud application and benefits. Likewise, in April 2016, the second Huawei Cloud Congress (HCC) West Africa was held in Lagos, Nigeria. The HCC was attended by more than 300 industry representatives from telecom carriers, finance, governments, and energy companies.[65] Huawei also completed a US$40 million contract to help cities in Ghana to meet demand for BD users.[66]

7.4.6 Philanthropic and Charitable Causes

Funding from philanthropic and charitable sources have also helped enrich the BD and cloud ecosystems. One notable example of such activities is Vital Signs,[67] which is a system that provides near real-time data and diagnostic tools in order to help relevant stakeholders inform agricultural decisions and monitor outcomes. The system was launched in Africa with a grant provided by the Bill & Melinda Gates Foundation to Conservation International.[68] This program is launched in several SSA economies in order to collect and integrate data on agriculture, ecosystems, and human well-being.

As of early 2016, Vital Signs research teams began collecting data in Tanzania, Ghana, Kenya, Rwanda, and Uganda. Some of the researchers conduct household surveys that deal with diver topics, such as nutrition, farming practices, and collection of water and fuelwood. Other researchers collect data on the landscape. For instance, soil samples are sent to Nairobi-based World Agroforestry Centre lab to analyze composition and measure organic carbon contents. The diameter, height, and canopy of trees are measured in order to calculate the amount of above-ground carbon held by forests. Measurements from satellite imagery are used to study land-cover changes such as the conversion of forest to farmland.[69] Using a tablet, Vital Signs researchers upload the information to a cloud-based data management and analysis system. The raw

data are then translated into indicators and maps for decision makers such as government agencies, civil society organizations, and farmer cooperatives.

Vital Signs and the Tanzania Ministry of Agriculture, Food Security and Cooperatives (MAFC) have formed a partnership to develop an implementation strategy for Climate Smart Agriculture (CSA).[70] Note that CSA is defined by the United Nations' Food and Agriculture Organization (FAO) as agriculture that can lead to a reduction in greenhouse gas emissions (GHGs) and an increase in agricultural adaptation and productivity. These measures can strengthen national food security and achieve various development goals.[71]

Likewise, the UK-based Indigo Trust funded over £65,000 (about US$100,000) to develop iCow. The fund helped to cover the core costs, legal fees, and customer care supports.[72]

7.5 Major Constraints Limiting the Development of BD and Cloud Industry and Market

There are also major constraints facing the BD and cloud industry and market in SSA economies, which are related to a low degree of digitization, the lack of infrastructures and bandwidth, unaffordable prices, narrow local cloud offerings, and unfavorable regulatory/human development issues.

7.5.1 A Low Degree of Digitization

In 2012, the Internet's contribution to Africa's GDP was estimated at 1.1 percent compared to emerging economies' average of 1.9 percent and developed economies' average of 3.7 percent.[73] A wide variation exists across SSA economies in the extent to which the Internet is helping economic growth. For instance, in Senegal and Kenya, the Internet was estimated to contribute 3.3 percent and 2.9 percent of GDP respectively. The corresponding contributions in Ethiopia and Angola were 0.6 percent and 0.5 percent of GDP respectively.

Unsurprisingly, most SSA economies have been unable to realize the benefits of modern ICTs. For instance, being able to accurately count the number of children is the first step towards realizing the benefit of BD and the cloud in health care. Many SSA economies have a notoriously poor record, even in registering the children born. Estimates suggest that only 44 percent of children under five years of age in SSA economies have been registered. The proportions are even lower in rural areas. In Eastern and Southern Africa, the proportion is reported to be 38 percent and it is estimated to be as low as 3 percent in Somalia.[74] Many people living in slums in countries such as Nigeria cannot provide birth certificates or utility bills required by banks. Financial institutions have imposed these oppressively burdensome requirements in order to prevent money laundering.[75]

The adverse effects of low digitization are felt across all economic activities, for instance, due to the low digital-payment penetration, only cash payments are accepted in most transactions. Consumers, banks, and governments in SSA economies thus suffer from the high costs associated with transactions on a cash basis. These include extra costs and inefficiencies that can result from manual acceptance of cash, record keeping, counting, storing, physical security, and transportation.[76]

7.5.2 Insufficient Infrastructures and Bandwidth

In Sub-Saharan Africa, 53 percent of urban populations and 8 percent rural populations have electricity (compared to 99% and 88% in North Africa, respectively). A significant proportion of users access Internet resources over limited bandwidths. For example, Sierra Leone's six million people had 155 MBPS available in 2011.[77] In 2011, Africa's international bandwidth was 801 GBPS.[78] However, North Africa (with a population of 200 million) had 433 GBPS, whereas SSA (with a population of 900 million) had 368 GBPS.

In 2011, Sierra Leone, the Central African Republic, Chad, the Democratic Republic of Congo, Eritrea, Guinea, Liberia, São Tomé, Príncipe, and Seychelles had no fiber optic links and users relied on satellites. While the situation has improved since then, fiber optic links in the region have been mostly limited to big cities.[79] Note that only 37 percent of Africa's population live in urban areas. Moreover, the unavailability of landlines makes it difficult to disperse bandwidth.[80] It is argued that the lack of fiber optic lines in most parts of Africa, especially in rural areas, makes the deployment of BD difficult.[81]

7.5.3 High Prices

First, it is important to note that there has been a dramatic reduction in costs for telecommunication services and related equipment. International bandwidth cost in Africa fell by 90 percent from 2009 to 2013.[82] The costs of drones used for anti-poaching are estimated to cost US$50,000–US$70,000 and higher-specification long-range drones can cost over US$250,000.[83]

Despite this reduction, and despite the fact that Internet and mobile phones are diffusing rapidly in the region, bandwidth is prohibitively expensive for most users. For instance, in early 2015, a 25 MBPS connection in Kenya was estimated to cost in the US$4,000–5,000 range per month in Kenya.[84] As a point of comparison, a 25 MBPS connection in 2014 cost US$23.69 in London and US$28.12 in Seoul.[85] According to the World Bank, bandwidth in Sierra Leone costs ten times more than in East Africa and twenty-five times higher than in the US Embassies', banks', and mining companies' 2 MBPS VSAT connections costing US$8,000 per month plus installation. The 512 KBPS connections, provided by ISPs through wireless networks, cost US$570 per month (plus a

modem charge of US$445). Mobile phone companies' distribution of satellite bandwidths packaged in USB sticks, which are extremely slow and unusable at busy times, cost US$70/month.[86]

Electricity and other infrastructures are also costly. Electricity in Kenya costs US$0.20/KWH, which is 50 percent higher than in the USA. Excluding cooling and management, running a Kenyan server costs over US$1,800 per year.

We noted above that South Africa's call center agents and software developers are increasingly using cloud-based systems to boost productivity. However, the high costs of telecom services have acted as a major barrier to the growth of South Africa's outsourcing industry.[87]

7.5.4 Narrow Local Offerings

Transferring data from foreign servers results in a latency of hundreds of milliseconds. Moreover, foreign companies require users to pay with credit cards, which, as of 2013, only 3 percent of the Sub-Saharan African population had.[88] Although local firms are leveraging competencies in some segments, they lack capabilities to serve most sectors.

7.5.5 Regulatory and Human Resources

Regulatory barriers often act as an inhibitor in the diffusion of BD and the cloud in SSA economies. For instance, Liquid needed to negotiate for two years in order to receive the permits required for taking its cable South Africa's Limpopo to Zimbabwe.[89]

According to the Business Software Alliance, South Africa ranked twentieth out of twenty-four economies analyzed in 2013 in cloud-related regulations. Other Sub-Saharan African economies are far behind. Only twenty-four countries were included in the study and South Africa was the only SSA economy included. Other Sub-Saharan African economies were not ranked in the study but they are further behind. Sub-Saharan Africa economies thus must strengthen regulations and train human resources.

7.6 Discussion and Concluding Comments

Factors such as low quality, the high cost of last-mile connections, the remoteness of many areas, and the unavailability of high-speed Internet pose opportunities and challenges to BD and cloud providers. The experiences of iCow and M2M indicate that less bandwidth-intensive interfaces and applications are appropriate for most Sub-Saharan African populations, which use the cloud for only a few activities.

We noted above that the entrepreneurial activities of large firms in the telecommunications sectors have facilitated the diffusion of BD and the cloud in SSA economies. However, there are limited entrepreneurial activities by new

firms in the ICT sector. For instance, according to the African Private Equity and Venture Capital Association (AVCA), ICT has accounted for only 10 percent of seed investments across Africa since 2007.[90] Likewise, there are a number of challenges to overcome for technology firms in SSA economies. For instance, according to GSMA's "Digital Entrepreneurship" survey, at least 70 percent of start-ups in Kenya were "not earning enough to maintain business and living expenses for a small team."[91] Government agencies, international organizations, the private sector, and other stakeholders need to team up to stimulate and facilitate entrepreneurial activities in BD and cloud sectors.

It would thus be unreasonable to expect that the cloud would allow Sub-Saharan Africa to catch up with the industrialized countries in one big leap. However, as the factors mentioned earlier improve, BD and cloud computing hold promise for bridging the digital divide.

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8

INDIA

8.1 Introduction

Some surveys have suggested that India's digitization rate is faster than the world average. For instance, digital information in India was estimated at 40,000 petabytes in the early 2010s, which is expected to grow to 2.3 million petabytes by the early 2020s. This growth rate that is twice as fast as the worldwide growth rate.[1] Gartner also expects India to be the fastest growing cloud market in the world.[2]

India's data center capacity was 1.3 million ft^2 in 2007, which is expected to reach 6.6 million ft^2 by the end of 2016.[3] One major shift that can be seen among Indian enterprises is the discontinuation of their own on-site data centers maintained by outside IT companies to move towards public cloud services offered by multinationals such as Amazon and Microsoft due to flexibility and cost-efficiency in data storage and processing services provided by the latter.[4] According to Gartner, India's public cloud services market in was US$423 million in 2013, which is expected to grow to US$1.3 billion in 2017,[5] and US$2 billion in 2018.[6] Similarly, according to a study conducted by the NASSCOM and Deloitte, titled "Deconstructing the Cloud: The New Growth Frontier for Indian IT BPO Sector," which was released in December 2011, the Indian cloud market will reach US$16 billion by 2020. Likewise, India's BD analytics industry is estimated at US$2 billion in 2016.[7]

Foreign CSPs are offering various incentives in order to attract customers and stimulate the growth of the cloud industry and market. Google has launched a program for start-ups, which provides qualified companies US$100,000 in cloud credits. Start-ups with revenue less than US$500,000 can apply for such credits.[8] Similarly, Microsoft offers start-ups US$60,000 in Azure cloud credits

and Microsoft Azure for BizSpark Plus Offer. Software start-ups which have revenues of less than US$1 million are eligible to apply. Likewise, IBM provides cloud credits to software start-ups based on their business plan.[9]

Local firms have also jumped on the cloud bandwagon. CRL, Zoho, and Tata Communications are high-profile Indian cloud providers.[10] Other big IT players such as TCS and Infosys have also entered the cloud market in India (see Table 8.1). In the same vein, Pressmart (based in Hyderabad) provides SaaS-based e-publishing and digitization services to the print industry. Pressmart can help firms deliver content across multiple platforms such as Web, mobile, RSS, podcasts, blogs, social networking sites, articles directories, and search engines.

Some Indian BD and cloud firms are acquiring foreign firms. For example, in early 2012, Bangalore-based Aditi Technologies acquired Cumulux, a US-based cloud start-up. Cumulux specialized in building, operating, and managing PaaS-based solutions. In September 2015, Snapdeal also acquired the Silicon Valley-based start-up Reduce Data, a display advertising platform. Reduce Data's platform utilizes AI and real-time data to help brands deliver advertising to consumers across platforms and devices.[11]

Cloud-related venture capital (VC) and other investments are also flowing. In February 2012, the Indian CSP Knowlarity announced an investment by the Silicon Valley-based VC firm Sequoia Capital. Knowlarity is a cloud telephony service provider, which offers communication tools such as interactive voice response (IVR), fax, and conferencing facilities to enterprises and individuals. The company's flagship products are SuperReceptionist and SmartIVR, which are reported to have capability to process over one million calls an hour.[12] As of 2012, Knowlarity had over 40,000 clients in India and Indonesia, including General Motors, Pepsi, and Procter & Gamble.[13] Japan's NTT Communications announced that it would buy a 74 percent stake in the Indian company Netmagic Solutions, which has cloud computing as a major business.

On the regulatory front, India is among the major developing economies with favorable laws and regulations related to some aspects of BD and cloud computing. For instance, according to the 2013 BSA Global Cloud Computing Scorecard, among the developing economies, India was among the leading countries in international harmonization.[14] Note that the lack of harmonization of international rules can hinder a smooth flow of data between CSPs in different countries.

Despite the encouraging achievements, the diffusion of BD and the cloud in India is being hindered by a number of factors, among which are regulatory issues, a lack of customized products, hosting location uncertainty, integration with various systems, unreliable power supply, and the quality, reach and reliability of internet connectivity.[15] On the regulatory front, for instance, the Indian government proposed a measure, which requires companies operating in the country to locate part of their IT infrastructure within the country. This requirement was aimed at providing law enforcement agencies with access to

data on servers in India. This measure also prohibits businesses from moving data related to Indian citizens and government organizations out of the country. Failure to comply would be a criminal offence.[16] Certain industry-specific restrictions also exist. For instance, RBI guidelines prohibit banks from storing customer data outside India, which may limit cloud adoption by financial services company.[17]

Just like in SSA economies (Chapter 7), India has a poor performance in data creation. For instance, many people living in slums in India cannot provide the birth certificates or utility bills required by banks.[18]

8.2 The Current State of BD and Cloud Industry and Market in India: The General Environment

The development and diffusion of BD and cloud are tightly linked to supply and demand. Demand is being strengthened through the increased availability of e-governance services and solutions for businesses and citizens—such as health care and educational services, drivers' licenses which have a propensity to switch to the cloud and online services for paying bills, receiving payments, obtaining land records, filing tax returns, and registering for benefits.

Among the key demand-side barriers to the diffusion of BD and the cloud are low Internet access and the lack of bandwidth. According to a BCG survey, in 2013, about 90 percent of SMEs in India had no access to the Internet, compared to 22 percent in China and 5 percent in the USA.[19]

The supply side is improving through various cloud-related R&D activities and increased development of its supercomputer industry. As noted earlier in Chapter 5, CLR's EKA supercomputer, which was the world's fourth fastest in March 2009, was used for joint cloud research with Yahoo.

However, most BD and cloud services rely on bandwidth, which is the most glaring shortcoming of India, especially in the rural areas. According to the International Telecommunication Union's World Telecommunication/ICT Indicators Database,[20] as of 2015, India had 1.34 fixed broadband subscriptions per 100 inhabitants. So although India is a heterogeneous cloud market with divergent demands, low cost rather than advanced performance is likely to be a driving force in the short run.

The lack of local data centers of some of the major foreign CSPs is another key barrier to the adoption of the cloud. For instance, India's nationwide cab-booking service Getmecab uses Amazon servers. As of 2012, the closest servers were in Singapore.[21] AWS Indian data centers were not operational until the mid-2015.

India's BD- and cloud-related initiatives are also handicapped by the shortage of manpower. In 2016, India was estimated to have more than 90,000 analytics professionals working in diverse areas.[22] India needs to deal with a talent deficit in this area. The labor market faces challenges on two fronts. First, there are not

sufficient BD engineers and scientists that are able to perform analytics. Second, many analytics consultants tend to lack the capabilities to understand, interpret, and put the data to work. Some estimates suggest that India will soon experience a shortage of one million data consultants. India's analytics professionals are reportedly paid 50 percent more than other IT workers.[23] India is finding it difficult to secure data *due to* technology and human resources constraints.[24] For instance, in 2011, India's Central Bank, the Reserve Bank of India (RBI), introduced a set of recommendations, which included the formation of separate information security groups within banks and the maintenance of adequate CS resources based on their size and scope of operation. In order to enforce the RBI guidelines, however, India requires a large number of CS auditors to evaluate the adequacy of controls in the management of project and business processes and validate banks' CS practices.[25] An estimate suggested that India had only sixty CS auditors in 2013.[26]

8.3 BD and Cloud Industry and Market in India

This section provides more detailed elaboration and analysis of demand and supply sides discussed in the previous section.

8.3.1 The Demand Side

According to NASSCOM and McKinsey, remote infrastructure management was a US$15 billion industry in 2013 in India. The 2011 NASSCOM and Deloitte report mentioned above noted that about two-thirds of the Indian cloud market would be new businesses and the rest would come from existing services. The NASDAQ-listed Indian IT company, SIFY Technology, announced that its revenue from cloud-based value-added services grew by 95 percent in the third quarter of fiscal year 2011–2012.[27] According to Zinnov Management Consulting's July 2011 report titled, *Private Cloud Landscape in India*, the cloud accounted for 1.4 percent of total IT spending in India in 2010.

A survey released in early 2012 indicated that 68 percent of Indian firms were using, evaluating, or planning to use the cloud within the "next year."[28] According to a survey conducted by the market research and advisory firm Current Analysis, which was released in September 2014, 68 percent of Indian enterprises with more than 100 employees were using the cloud.[29] Especially large firms have benefited from BD and the cloud. For instance, as of 2014, Reliance Entertainment, the motion picture arm of India's Reliance, was reported to have 40 percent of total IT workload on AWS.[30]

Government agencies are among the biggest users of the cloud. The government has launched projects such as Aadhar, National Population Register, National Rural Heath Mission, and the flagship rural job scheme, Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA).[31] These projects

make extensive use of the cloud. For instance, India's Unique Identification Card project, which aims to provide a unique twelve-digit number to every resident in the country, is probably the most visible and sophisticated e-governance project from the cloud standpoint.[32] Likewise, in order improve MNREGA's implementation, the Indian government started a mobile monitoring system (MMS) in 2015. The plan is to cover 35,000 gram panchayats, the village level administrative bodies. The plan is to give a tablet to each gram panchayat. The initiative involves monitoring performance with real-time data from the worksites. The assets will be located with geo-tagging for verification.[33]

8.3.1.1 Remote Infrastructure and Offshore Growth

Since India is considered to be an outsourcing capital of the world, the effects of BD and the cloud on India's offshoring industry deserve special consideration. BD and the cloud computing should affect India's offshoring industry. The demand for cloud services is especially high in the offshoring industry and technology hubs such as Bangalore and Delhi. Amazon noted that its Indian customers, especially those serving international markets, were showing increased interest in its cloud services. The 2011 NASSCOM and Deloitte report mentioned above noted that cloud computing will have a significant impact on the IT and BPO services industry. The cloud should help Indian firms diversify the services offered, and improve the business models and delivery mechanisms.

India's software and outsourcing companies' business models mainly rely on inexpensive Indian engineers, who visit Western clients' sites in order to fix problems. CSPs use external servers and sophisticated technologies to do the same using fewer employees. According to the management consulting firm Insight Sourcing Group (ISG), one employee can monitor up to 200 servers in traditional service providers such as those in India. CSPs, on the other hand, can use one employee to monitor as many as 10,000 servers. In recent years, CSPs such as AWS, Red Hat, and Rackspace Hosting are reducing prices, which has posed a significant threat and challenge to the Indian software and outsourcing companies.[34]

8.3.2 The Supply Side

Foreign and local BD and cloud providers are operating under intense competition and low-average profit margins in India. The activities of these players have enriched the Indian BD and cloud industry.

8.3.2.1 Global BD and Cloud Players

Given the rapid growth, it is not surprising that India has received considerable attention from global BD and cloud players, including IBM, Microsoft,

VMware, Parallels, and Salesforce.com. In 2008, IBM opened a cloud center in Bangalore for mid-market vendors, universities, government bodies, and microfinance and telecommunications companies. Then, in early 2012, it helped India-based Tulip Telecom construct a 900,000 ft^2 data center—the largest in the country—which will provide cloud infrastructure services.[35] The company expanded the operations and services by establishing its first cloud data center in Airoli, on the outskirts of Mumbai. IBM's Airoli data center is a 30,000 ft^2 facility.[36] IBM heavily spent on advertising to market its Softlayer cloud.[37]

In 2009, Microsoft started offering productivity apps on the cloud for approximately US$2 per month which included email, collaboration, and conferencing services. In 2014, Microsoft Office 365 was available for US$5.50/month or US$55/year in India.[38] In the beginning, while Indian companies used Microsoft's cloud services, the data centers were located in foreign countries.[39] In 2014, Microsoft announced plans to open local data centers in three Indian cities.[40] In 2015, it started three cloud data centers in order to improve the performance of Azure services for Indian customers. The three centers were located in in Pune, Chennai, and Mumbai, serving Central India, South India, and West India respectively.[41]

As of August 2014, over 8,000 Indian companies had used AWS.[42] Amazon completed the construction of its five data centers in Mumbai in the early 2016.[43] In June 2016, AWS launched the Asia-Pacific (Mumbai) Region to serve its 75,000 India-based consumers.[44]

Salesforce.com started operations in 2005. It has many high-profile clients in India, including Bharti, eBay India, SIFY Technology, Polaris, and the National Research Development Corporation. In September 2011, Salesforce.com acquired a social customer-service SaaS start-up, Assistly, for US$50 million. Assistly's users can benefit from metrics and analytics which include case volume, interaction volume across different channels, response time, service levels, agent performance. Assistly's acquisition is expected to help attract SMEs in India and other countries.[45]

In August 2014, the US-based cloud solutions providers for price quote, e-commerce, contract management, and revenue management, Apttus, announced a US$15-million investment plan for India. The company had started India operations in 2012.[46]

In 2009, VMware opened a cloud center in Pune. VMware provides cloud and virtualization software and services. As of 2015, VMware had 3300 employees in India. Its R&D division had 1,300 employees. VMware's second largest R&D center after Atlanta is in India.[47]

The hosting software provider Parallels announced a plan in 2009 to establish cloud operations in India. Parallels reported that data services providers in India use Parallels Plesk Automation and Parallels Plesk Panel to manage customers.[48]

In February 2016, DigitalOcean announced plans to establish a data center in Bengaluru. DigitalOcean is a public cloud host, which specializes in Linux. In

March 2016, Oracle announced the launch of "cloud machine," which allows companies to bring public cloud in their on-premise data centers. Oracle also announced plans to set up its data center in India.[49]

It was reported in mid-2016 that Alibaba is expected to open a data center in India. Its AliCloud public cloud services will compete with global CSPs such as AWS and Microsoft.[50]

Some foreign technology companies have engaged in R&D activities to generate new products for the local market. For instance, Novatium, which is partly owned by Ericsson, developed cloud-based mobile applications, mainly in its Indian R&D centers. In September 2011, Novatium services had over 40,000 users in India. Ericsson's principal target groups for the applications are emerging markets, where most consumers cannot afford a PC. In developed markets, the company aims to focus on young consumers.

8.3.2.2 BD- and Cloud-Related Local Entrepreneurship

Platforms developed by global players have provided developers in India with opportunities to build BD- and cloud-based applications. Indian firms have also engaged in higher-end entrepreneurial activities in BD and cloud sectors.

Table 8.1 presents BD- and cloud-related business and entrepreneurial activities in India. As of 2016, India was estimated to have over 600 analytical firms, including about 400 start-ups.[51] Indian firms are playing an increasingly prominent role in the global BD and cloud landscapes.

Some Indian BD and cloud players are also engaged in R&D activities in foreign locations. For instance, the Indian e-commerce giant Snapdeal has opened a Data Sciences Centre in California to focus on BD and advanced analytics to understand consumer behavior.[52] As noted above, Snapdeal also acquired the Silicon Valley-based start-up Reduce Data.[53]

8.4 BD and Cloud Computing Apps in India

BD and cloud providers in India have developed products, services, and applications to meet diverse customer needs. Some have developed specialized applications to meet the demands of specific industries and sectors.

8.4.1 E-Commerce and CRM

India's largest retailer, Future Group,[54] uses the cloud to support data warehousing and analytics for its retail chains. The retailer uses clouds to manage its customer loyalty program, which involves storing and analyzing millions of gigabytes of data.[55] In September 2014, Future Group announced measures to make shopping from online and brick-and-mortar stores a seamless experience, known as an omni-channel strategy.[56]

In February 2011, Dr. Reddy's Laboratories deployed Salesforce CRM to improve its deals pipeline, track sales cycle, and analyze sales funnel. Dr. Reddy's expected cloud-led streamlining to increase revenue by over 30 percent.[57]

8.4.2 Investment, Banking, Finance, and Insurance

BD helped India's ICICI Bank to enhance operational efficiency by improving debt collection without alienating customers. The bank has digitized processes that used to be performed by agents in the field. The bank's BD system captures the details of delinquent cases. Parameters such as risk behavior and customer profile are used in the model. It matches each case to the most appropriate collection channel, such as email, phone calls, and letters, which are less intrusive. It was reported that in auto loans, the bank increased debt collections by 50 percent. In some areas, manpower needs were reduced by up to 80 percent.[58]

Likewise, ICICI's insurance arm has used Zoho's web-based applications to develop innovative services such as a personalized insurance for diabetes.[59] Premiums are adjusted depending on how well the policyholder sticks to his or her fitness plan.

The Central Bank of India, which as of mid-2016 has served more than 35,000,000 account holders through 4,400 branches, six extension counters, twenty-nine satellite offices, 2,413 ultra-small branches, and about 2,000 ATMs,[60] uses BD to enhance corporate performance management. BD allowed the bank to cut planning time by half and improve the accuracy of reporting. It tracks deposits and loans at its branches. It uses BD to reduce liquidity risk and understand the impact of changes in interest and foreign exchange rates.[61]

In October 2010, Intel announced an agreement with an alliance of seventy companies, including the Bombay Stock Exchange (BSE) and CtrlS,[62] to develop hardware and software for an open and interoperable cloud. The Open Data Center Alliance works to address security, energy efficiency, and interoperability. The BSE expected that the new trading platforms supported by mobile telephony and clouds would broaden participation by allowing real-time and seamless access to data across phones, laptops, and other devices. This approach would also deepen and widen asset classes traded by increasing the participation of younger Indians in pension, insurance, and mutual funds. The popularity of mobile-based cloud applications is particularly promising. As noted above, India has many times more mobile subscribers compared to Internet users.

Ekgaon, which provides agricultural information to farmers, has developed a cloud-based free software for micro-finance institutions (MFIs). Using a mobile app, MFIs can track transactions in real-time. MFIs' use of the open-source software is expected to reduce operating costs by 25–30 percent. In order to serve rural customers, MFIs have typically relied on field officers, who use traditional paper-based recordkeeping. Transaction approvals and executions were

TABLE 8.1 Big Data- and Cloud-Related Business and Entrepreneurial Activities in India

Company	*BD- and Cloud-Related Activities*
Infosys	• Infosys has partnered with its major clients in cloud research and, in 2010, it dedicated 175 engineers to identify potential cloud-related applications (www.infosys.com/cloud/Pages/index.aspx). • April 2016: teamed up with AWS to enable clients to move enterprise workloads to the AWS Cloud. Infosys will also use AWS's BD analytics. Infosys will also support organizations' transition from legacy technologies to the AWS Cloud.[1] • This cloud system integrator provides cloud-based services for the auto sector and Finacle Lite for rural and semi-urban banks (www.infosys.com/finacle/solutions/pages/lite.aspx).
Computational Research Laboratories (CRL)	• In 2008, Yahoo signed a research pact with CRL to support cloud research.[2] • CRL is a lab run by the Tata Group. Yahoo used CRL's EKA supercomputer.
Zoho Corp (formerly AdventNet)	• Zoho's Word processing, spreadsheet, presentation, and chat applications are free for personal use. It also offers inexpensive accounting, invoicing, and recruiting tools for business. • Zoho operates a popular suite of Web-based productivity, business, and collaboration apps. • These apps had over 5 million users in September 2011.[3] ICICI bank's insurance arm uses Zoho's applications to develop personalized insurance for diabetes. • ZohoCRM is a cloud-based CRM software for managing customer relations. It helps manage sales, marketing, customer support, and inventory management. As of 2013, the *Enterprise* version of ZohoCRM cost US$35 per month per user. A free version was available for less than three users. It is also referred to as "poor man's Salesforce.com."[4] • Zoho Books is SaaS-based accounting and bookkeeping tool. In 2011, it cost US$24/month for two users and US$5/month for each additional user.[5]
Tata Consultancy Services (TCS)	• TCS applications include human resources, finance, inventory, ERP solutions, email, document management, and website services. Helped Singapore Management University set up a lab focused on the cloud, committing US$6 million. • TCS started cloud pilot projects in 2009. It launched the iON cloud network (www.tcsion.com) exclusively for SMEs, which had 135 customers by February 2011. Its clients were expected to increase to 1,000 by 2011-end. As of the mid-2011, TCS has a strong R&D backbone consisting of 20 cloud centers. • 2012: TCS acquired CRL. The acquisition is expected to help TCS to offer integrated High Performance Computing (HPC) and cloud applications to its customers.[6]

Tata Communications	• Its infrastructure-as-a-service offering, InstaCompute (http://instacompute.com), aims to rival Amazon.com's Web services. As of March 2011, 40–45 percent of InstaCompute customers were from outside India.[7] • InstaCompute capitalizes on the company's 300,000 ft^2 data centers in India and Singapore. The company plans to expand to the UK and the USA. • May 2016: launched IZO Cloud Storage platform, which offers storage solutions for enterprises. The platform is supported by its subsea cable network.[8]
Wipro	• Its BD solution: Big Data Ready Enterprise (BDRE) simplifies BD adoption.[9] BDRE is offered for both individuals and organizations. • BDRE is an open platform, which makes easier to customize BD solutions for industry verticals and different use cases.[10] Wipro has partnered with Santa Clara, California-based business computer software company Hortonworks to open source its BD technology.[11]

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thus slow. Using Ekgaon, field officers can communicate loan requests, receive loan approvals, and record cash transactions via text message. The information is stored in a cloud server. The software also helps track transactions accurately and reduce frauds.[63]

8.4.3 Education

Indian universities, including the Indian Institute of Technology, Kanpur, are banking on the cloud to develop innovative research and education activities.[64] In January 2012, the Indian government launched the country's first cloud-based tablet, known as the E-tutor Tablet, targeting first- through twelfth-grade students. The content for the US$150 tablet was developed by e-tutor and the technology was designed by Oztern Technology.[65] In April 2012, Microsoft announced its biggest global cloud deal, which would provide free services to All India Council for Technical Education (AICTE). As part of Microsoft's corporate social responsibility (CSR) initiatives, the project will make resources on the cloud available to 7.5 million students and 450,000 teachers in 11,000 AICTE-affiliated institutions.[66]

8.4.4 Health Care

An innovative application in the early phases of development aims to identify counterfeit or sub-standard drugs.[67] When buying a drug at a pharmacy store, a customer can find a twelve-digit code by scratching a sticker on the surface of the package and then send a text message to a given number. The code sent by the customer is matched with that registered by the pharmaceutical company in HP's cloud database. The customer then receives a response back that tells them whether the drug is counterfeit or genuine.

Although this application provides obvious commercial benefits to drug manufacturers and patients, one of the most important benefits of this technique is that it helps save lives by enabling the customers to check the authenticity of life-saving drugs. This system was developed in Africa by the non-profit organization, mPedigree, and HP Labs. The technology provider had launched a program to track and authenticate drugs in Nigeria and Ghana. As of September, HP was negotiating with Indian pharmaceutical companies such as Cipla, Tablet India, and CAMA. This application holds a special appeal for India, as the number of cellphone subscribers in the country is more than seven times higher than the number of Internet users.

The Medical Informatics Group of the Centre for Development of Advanced Computing in India has made the Mercury Nimbus Suite available for healthcare service providers. This suite offers tele-medicine services to people in remote areas through public and private cloud.[68]

One application that has made health care accessible to the broad public is the US$600 cloud-based medical device called the Swasthya Slate.[69] This small

device performs thirty-three common medical tests. It measures blood pressure, blood sugar, heart rate, blood hemoglobin, urine protein, and glucose. It also tests for diseases such as malaria, dengue, hepatitis, HIV, and typhoid. Each test takes only a few minutes and the data is uploaded to a cloud-based medical-record management system, which can be accessed by the patient.[70] In areas that lack Internet connection, the data can be stored on the Android phone or tablet. When connection is available, the data can be uploaded. The device can also use SMS to upload data.[71] The device supports English, Hindi, Urdu, and Telegu languages. In March 2014, the Indian government launched a pilot project which involved the deployment of 4,250 Swasthya Slates in six districts of the northern state of Jammu and Kashmir. It is expected that the cost of the Swasthya Slate may reduce to US$150 per unit with a wider diffusion.[72]

8.4.5 Environmental Monitoring and Resource Protection

Bharat Light and Power (BLP), one of India's largest clean energy companies, combines cloud computing, BD analytics, mobile phones, and social media technologies in order to improve efficiency. Using IBM's SoftLayer technology, BLP has built a cloud infrastructure to manage and monitor its large number of wind farms across the country. Using the infrastructure, BLP stores, manages, and uses the huge amount of data produced by its power generation sources. BD analytics will help draw insights from the data in order to increase operational efficiency and production capacity. For instance, it is possible to proactively identify defective equipment and causes related to capacity utilization problems. Using mobile phones, information can be provided to the ground staff on their handsets, who can take corrective actions before the problems occur. The future plan is to utilize social media to connect with customers and inform them about their power usage. It will also help them determine energy demand and improve energy distribution on its farms.[73]

India's tiger poachers are familiar with the jungles so that they can easily move around and kill the animals. Poachers outnumber officers by a big factor. BD can be used to pinpoint poaching hotspots, and direct more resources. Information could be collected from reports related to captured or killed tigers or the locations of traps that have been discovered. Analyzing information collected this way over time would determine the areas where poaching activities are most likely to occur. Analytical process can also be used to determine the locations where tigers tend to travel throughout the year, and where they are likely to be attacked by poachers. Such information can be combined with environmental data to create models, which could help understand if poaching is more likely to occur at night, at dawn, when a full moon is out, or during the dry season.[74]

Tigers are being monitored with satellite tracking software that was originally developed for industrial use. The software is adapted to track tigers using

crowdsourcing. For instance, with more than 6,000 tourist photos that were tagged with details of locations and times, Tiger Nation and the Born Free Foundation reportedly tracked about 300 tigers in six parks.[75]

In the capital city, the Municipal Corporation of Delhi and the Public Works Department use BD to improve lighting in the city.[76] The city plans to replace 18,500 street light poles with LED and install CCTV cameras on them in order to monitor crimes. The city also hopes to generate at least 4 MW of solar energy by optimally utilizing rooftops of government buildings.[77]

The cloud-based IGG (I Got Garbage) platform seeks to improve the way garbage is disposed of and recycled in India.[78] It was developed by the global technology services company Mindtree in collaboration with the NGO Hasiru Dala, Waste Wise Trust, and seven other social businesses. It is expected to enhance the working conditions of waste pickers (also known as ragpickers) and integrate them into the formal economy. Currently the ragpickers go to the garbage piles, segregate items, and sell them to the waste collectors for recycling. The working conditions are hazardous and unsafe. Consequently a ragpicker's average life expectancy is thirty-nine years with a one-in-three infant mortality rate. They also lack access to the mainstream supply chain of waste. The IGG was being tested on a limited basis in the early 2014 in Bangalore which has about 25,000 waste pickers. The app allows apartment buildings, NGOs involved in educating people about proper disposal of solid waste, scrap dealers, garbage contractors, ragpickers, and other relevant groups to coordinate efforts using centralized information in the cloud. The project expects to increase a ragpicker's income from about US$65 to US$110/month.[79]

8.5 Discussion and Concluding Comments

Overall BD and cloud computing are yet in their infancy in India. The key problems include unpredictable power supplies, poor quality Internet connection, limited bandwidth, and unreliable optical fiber links connecting different parts of the country.[80] Significant regulatory barriers to BD and cloud computing also remain. But, as is the case of other developing countries, as economic and institutional factors improve, it could greatly accelerate India's digitization and transform how cellphones and other technologies are used. If industry and the government adopt appropriate measures such as developing appropriate products that meet local needs (e.g., mobile cloud) and addressing issues such as the low bandwidth, communicating the cloud's value proposition, addressing security issues, and enhancing trust in vendors, the cloud might serve as an important catalyst in driving economic and social progress and development in India. For instance, about 400 million residents lack electricity access in India. Using BD and the cloud, it is possible to reduce the gap between demand and supply. Companies such as BLP are taking measures on this front.[81]

BD- and cloud-based apps are likely to bring social and economic changes. In order to illustrate this point, we take examples related to the access to finance. In India, in 2014, over 400 million people borrowed money. However, less than one in seven were approved for a formal loan. Many individuals in developing countries are "invisible" to formal lenders as no data exists on them.[82] BD has the potential to transform this landscape. Using BD, it is possible to expand the number of individuals in India who could gain access to formal credit by 100–160 million. In China, Brazil, India, Mexico, Indonesia, and Turkey, the six biggest developing economies, BD has the potential to help gain access to formal credit for 325 million and 580 million people.[83]

As is the case of most developing economies, for global technology companies, affordability will be a key consideration to compete in India. A related point is that BD- and cloud-related products and services offered in India must recognize the local technological reality, such as low bandwidth and mobile-driven digitization.

Foreign companies could benefit by collaborating with local cloud providers, characterized by lean cost structures and experienced in developing low-cost products. For Indian cloud providers, on the other hand, their ability to deliver value for money in the domestic market could give them a competitive advantage in foreign markets, especially if they are in a position to reconfigure their resources to operate effectively in emerging markets.

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9

CHINA

9.1 Introduction

China's BD industry is expected to grow by 50 percent annually during 2016–2020. Especially industries such as retail and manufacturing are rapidly embracing BD technologies. For instance, according to KPMG's fourth annual "Global Consumer Executive Top of Mind Survey" released in mid-2016, about two-thirds of executives in China and Hong Kong had plans to use data and analytics, telematics, geospatial or location-based technology, and virtual reality by 2018.[1] With these and other developments, by 2020, China's data volume is expected to make up about 20 percent of the global total.[2]

Likewise, according to the consultancy Bain & Co., the Chinese cloud computing market in China was worth US$1.5 billion in 2013, which will increase to US$20 billion by 2020.[3] According to the *China Securities Journal*, China's cloud computing market is expected to reach US$6 billion in 2017.[4] Likewise, the China Software Industry Association estimated that the country's overall cloud-computing value chain will exceed US$122 billion by 2015.

China's BD and cloud computing industry and market are a result of a number of contradictory and conflicting forces. On the one hand, the Chinese government has viewed cloud computing and BD as a strategic industries.[5] It has mobilized massive resources to develop the country's cloud computing and BD sectors. For instance, the government plans to spend billions of dollars in the cloud computing industry in the 13th five-year plan between 2016 and 2020.[6] In May 2016, the Chinese Ministry of Industry and Information Technology announced that it would release a national Big Data development blueprint in the second half of 2016. The goal is to use BD analysis technologies and applications to create a revenue of seventeen billion yuan (US$2.6 billion) by 2017.[7]

On the other hand, thanks to a strong emphasis on cyber-control measures, most foreign CSPs have located their servers in neighboring countries. Requiring foreign-originated traffic to pass through China's firewall often leads to long loading times for Chinese consumers. A study of the content delivery network provider CDNetworks indicated that China's firewall leads to an increase in load time by 450 milliseconds or more for an object hosted on a server outside China. For a typical website hosted in Asian cities such as Hong Kong, Singapore, or Tokyo, the firewall adds 10–15 seconds. The average time to load an object from a Hong Kong data center is 50 percent longer than in China. Websites hosted in the USA take 20–40 seconds to load.[8] Thus, accessing cloud services provided by foreign vendors, such as Google Docs and Dropbox, is difficult or impossible. Moreover, if a cloud provider's contents are on a server that also hosts content objectionable to the Chinese government, they might be blocked.[9]

In the Asia Cloud Computing Association's (ACCI) Cloud Readiness Index 2016,[10] China ranked thirteenth out of the fourteen economies analyzed. The ACCI noted that programs such as the 12th Five-Year Plan and the Chongqing cloud computing special zone have been major positive steps taken by China. Note that the country's 12th Five-Year Plan (2011–2015) has targeted to spend US$308 billion for the telecommunications infrastructures. There are tax and other incentives for investments in the cloud industry.[11] Likewise, in 2011, China announced an investment of US$154 million to develop a cloud center for high-tech and start-up firms in Chongqing. The cloud computing Special Administrative Region (SAR) would be free from censorship.[12] The ACCI expressed concerns in issues such as data sovereignty, the stability and power quality of power grid, green energy and freedom of information access.[13]

In addition to the apparently paradoxical policy position of the Chinese government, the development of the Chinese BD and cloud industry and market also needs to be looked at in the context of contradictory economic dynamics. For instance, in 2013, China overtook Japan to become the world's second largest IT market,[14] which suggests a strong demand of BD analytics and cloud services in the country. Despite the potential attractiveness of China's cloud market, Chinese firms have exhibited a lower propensity to adopt the cloud compared to industrialized countries. For instance, according to the market research firm, International Data Corporation, only about 4 percent of companies in China were using the cloud in 2009 compared with 16 percent in Singapore.[15] Likewise, by the end of 2013, only 5 percent of Chinese SMEs had used hosted servers.[16] In the same vein, according to a July 2014 report of the McKinsey Global Institute (MGI), only about a fifth of Chinese firms were using the cloud, which compared unfavorably with those of US peers, where about three-fifths used the cloud. The report also noted that Chinese businesses in the average spend only 2 percent of revenues on IT, which is half as much as the global average.[17] Slow and unstable broadband networks and poor customer

service have also hindered the diffusion of the cloud in China. For instance, whereas download speeds averaged 17.4 MBPS in developed countries in 2013, it was only 4 MBPS in China.[18]

Institutional theorists have emphasized the importance of formal and informal institutions in shaping the developmental patterns, industries, and markets.[19] The idea here is that various policies, rules, laws (formal institutions), as well as cloud providers' and cloud users' norms of behavior, mental maps, and codes of conduct (informal institutions) are tightly linked to the diffusion pattern of the cloud in China. Formal and informal institutions in China have a number of interesting aspects from the standpoint of modern technologies such as BD and the cloud. In this chapter, we thus use the institutional angle to analyze the development of the Chinese BD and cloud industry and market.

Moreover, prior researchers have suggested that the developmental pattern of an industry is tightly linked to the forward linkages (demand), backward linkages (supply), and horizontal or inter-sectoral linkages.[20] This means that cloud industries and markets are embedded in the broader economy and thus their development should not be viewed as a self-contained phenomenon with self-contained solutions.

9.2 The Current State of the Diffusion of BD and Cloud Computing in China

The development of China's BD and cloud computing industry and market is associated with and facilitated by a rapid growth in its information economy. In 2015, China's information economy was estimated at 18 trillion yuan (US$2.8 trillion) and its e-commerce transaction volume exceeded 20 trillion yuan (US$3.1 trillion).[21]

In 2013, there were more than forty public cloud projects in China. Beijing had received more than US$8 billion to support projects in constructing servers and other infrastructure.[22] Even the rural and backward areas of the country are benefiting from BD and the cloud. In 2016, the Guizhou province, which is one of China's poorest provinces, reported that its BD "industrial value" was 200 billion yuan (US$31 billion).[23]

In 2011, China spent US$286 million on cloud computing infrastructure.[24] Due to the newness, the cloud computing industry's growth will require a large amount of capital. Industry experts believe that cloud projects could also be funded through the capital market.[25] One estimate suggested that Chinese companies accounted for 10 percent of the global investment in cloud computing in 2011. Many large companies have invested heavily in data centers. Local governments have also announced cloud computing parks to support the data centers.[26]

According to Forrester, China's public cloud market was US$1.8 billion in 2015, which is expected to grow to US$3.8 billion in 2020.[27] Some sample

examples that can illustrate the cloud's impact on businesses and consumers are shown in Table 9.1. The country is also planning the implementation of other cloud-based applications such as a food safety cloud to monitor food growers.[28] Cloud-related offerings of Chinese entrepreneurial firms are presented in Table 11.2.

Foreign CSPs have deepened their involvements in the Chinese market. Apple has started to store the personal data of some Chinese users in Chinese servers. Its first iCloud data center in mainland China was built in collaboration with China Telecom.[29]

In December 2013, Amazon.com announced its entry into the Chinese market.[30] In order to make AWS available in China, AWS has partnered with local technology companies. Under the arrangement, Amazon provides software, whereas Chinese partners provide local data centers, bandwidth, and content delivery.[31]

IBM announced a deal with Chinese data center service provider 21Vianet Group to launch its Bluemix cloud computing platform in China.[32] And 12 IBM has invested US$1 billion in Bluemix, which supports more than 120 tools and services.[33]

9.2.1 BD- and Cloud-Related Entrepreneurship of Chinese IT Firms and Their Offerings

Chinese firms have engaged in substantial entrepreneurial ventures to serve the domestic and international markets. For instance, Huawei's global sales of servers associated with the cloud increased by 130 percent in 2011.[34] The company's goal was to increase cloud businesses originating from outside of China from 25 percent in 2011 to 60–70 percent in 2012.[35] Likewise, in 2012, Lenovo acquired the US software company Stoneware in order to strengthen its cloud computing.[36]

Cloud players in China are also gaining increasing prominence. For instance, China Life and the government-owned telecommunications company, China Unicom are represented in the Intel-backed cloud standards organization—the Open Data Center Alliance.[37]

9.2.2 Mega Projects and Investments Involving BD and the Cloud

Chinese IT players are involved in grand projects and investments. A highly visible example is the state-of-the-art 6.2 million ft^2 Cloud Center in Langfang city constructed by IBM and China's Range Technology, which will be comparable to the Pentagon and 646,000 ft^2 will be devoted for data center.[38] After its completion in 2016, the Center will be the largest of such facilities in Asia.[39]

TABLE 9.1 Big Data and Cloud Computing Applications and Their Impacts in China: A Sample of Examples

Cloud Application	*Example*	*Explanation*
Enhancing efficiency with e-commerce/ e-business	IBM's Project Yun	2008: a pilot project was started to provide access to cloud-based business services: Project Yun (Chinese for "cloud"). It dynamically allocates storage, server and network resources. Wang Fu Jing Department Store, one of China's largest retailers with more than 10 million customers, has benefitted from Project Yun.[1] It uses the cloud to share information with retail stores and implement B2B e-commerce with suppliers.
Reduction in capital expenditure	IBM Cloud Center Wuxi	Supports software developers across hundreds of companies.[2] The tenants, mostly SMEs, have access to IT infrastructures and enterprise-ready environments.
Development of new or improved products/services	China Mobile The city of Ningbo	Expected to enhance mobile Internet and 3G experiences. Is working with IBM to develop a cloud-based Smart Logistics Center to streamline the port's supply chain. The system will allow the 5,000 logistics companies to share data. Connecting every shipping vehicle with a GPS tracker has led to the reduction of the idle times of trucks. A trucking company reported an 80 percent decline in idle time.[3]
Extending market reach	China Mobile	Expected to diversify demand.
E-health	Guang Dong Hospital	Implementation of a suite of healthcare data-sharing and analytics.
E-environment	Beijing municipal government	July 2014: the Beijing municipal government and IBM signed a deal to use the latter's advanced weather forecasting and cloud technologies to solve the city's pollution problem. IBM's technologies will make optimizations and adjustments to make a better utilization of renewable energy sources. In a project implemented in Zhangbei in Hebei province, the deployment of IBM's supply and demand management system led to a reduction of energy waste from 30% to 20%.[4]
Food safety	The province of Guizhou	Food Safety Cloud of the Guizhou Academy of Testing was established in 2014. As of the mid 2016, it involved the participation of more than 20,000 enterprises and hundreds of testing agencies. It had data on 35,551 products. The plan is to include storage, transportation, and other data from "the farm to the dining table." Consumers can access all the relevant information using the mobile app "Shi-An-Ce" (test for safe food). The app scans bar codes to show all the available data on food products. Guizhou is also developing BD platform for this purpose.[5]

Policing and law enforcement	The city of Guiyang	Guiyang Public Security Bureau (GPSB) uses BD and the cloud in law enforcement. Law enforcement personnel wear body cameras that record all activities. The system can help stop malicious behaviors such as tampering of test results, which were common in the past. For a drunk-driving test, as soon as the breath test begins, the results are uploaded in real-time on a cloud via 3G networks. In one year after the adoption of BD, there was a 50% reduction in traffic-related cases. The system is also expected to reduce corrupt practices of police.[6]
Banking and finance	Alibaba's Sesame Credit	It was launched in January 2015, which provides credit ratings of consumers and small businesses. Sesame mainly utilizes data from Alibaba's huge online ecosystem. It also makes use of BD collected from Alibaba's various partners, as well as the online and offline history of transactions. Sesame provides credit providers with more accurate and data-driven insights, which can help assess potential borrowers' creditworthiness and offer loans and micro-finance and other credit-related services.[7]

Notes

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TABLE 9.2 Some Examples Big Data- and Cloud-Related Entrepreneurship of Chinese Firms

	Example	*Explanation*
Offering for SMEs	• IBM and the Wuxi National Software Park	• Launched PangooSky platform for SMEs.[1]
	• Alibaba Group's Aliyun	• 2009: announced US$146 million investment in software development, marketing and establishing cloud centers for customers, especially SMEs.[2] • Its cloud business, Aliyun had a revenue of US$102 million in 2013.[3] • March 2015: Alibaba launched its first U.S. data center in Silicon Valley.[4] • August 2015: Aliyun announced the launch of "China's first" BD platform, DT PAI, which will allow app developers to better predict user behavior. The system studies huge amount of data to create forecasts.[5] • October 2015: Announced an investment of US$1 billion in its cloud computing business globally to compete with AWS. Opened second data center in Silicon Valley.[6]
	• Shanda	• GrandCloud.
Offerings for large enterprises or specialized business needs	• Huawei • ZTE	• IaaS solution for operators, governments, and enterprises with data center IT infrastructure. • Initial customers are telecom operators, government agencies and the military.
Offerings for foreign markets	• Huawai	• Cloud as a critical component to serve foreign markets. • Has 45 out of the world's 50 biggest telecommunications operators as customers (China Daily, 2011). • As of the mid-2012: collaborated with 85 customers in 33 countries on the cloud's commercial use. • Cloud bases in Southeast Asia, the Middle East, Southern Europe and Eastern Europe.[7]
	• Alibaba	• Has opened a data center in Silicon Valley. • June 2016: Alibaba-backed mobile Internet company, UCWeb launched a BD-based news app for India: UC News. The app uses BD to aggregate news for individual users. UCWeb's UC Browser was reported to have 400 million monthly users worldwide.[8]
Offerings for individual consumers	• Tencent	• 2010: Launched cloud-based QQ mobile browser. Users would be able to store pictures and files. It also provides a seamless interface between mobile devices and PCs.

• Ubitus and China Mobile	• 2010: launched mobile gaming based on BigCloud.
• Huawei	• Cloud+ platform.
• Baidu	• Has made heavy investment on AI, especially autonomous driving. It has collaborated with the Wuhu city government in the province of Anhui for a dedicated unmanned car testing zone.[9] • Announced that it is developing unmanned bicycles called a "smartbike," which will use advanced intelligent sensors and cloud-based BD analysis. The bicycle will know the owner's requirements and health index and will be able to drive by itself. By 2013, China had 551 million bicycles, of which 81 million were electric.[10] • Operates data centers around the country, which includes a 120,000 square meter facility in Shanxi province.[11] • Deployed cloud applications such as Baidu Wenku (Baidu Books).[12]

Notes

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In August 2015, China Mobile completed the first phase of its data center in Hubei Province's Xiangyang Hi-Tech Industry Development Zone. The Xiangyang data center is scheduled to be completed in four phases with a total floor area of 327,000 square meters. The construction started in March 2013. As of August 2015, the data center was offering data operation, storage, and transmission services for twenty-three internet companies, enterprises, and municipalities.[40] In September 2015, China Mobile announced plans to invest US$6.3 billion by 2019 to expand its cloud computing facilities in central China's Hubei province. China Mobile also signed a strategic agreement with the Hubei provincial government for the smart city project "Smart Hubei" during 2016–2020.[41]

China's three state-run telecommunications operators, China Telecom, China Unicom, and China Mobile, announced plans to invest US$47.4 billion in data centers in Chengdu, the capital of Sichuan province, to create a cloud hub.[42] China has also established Cloud Centers in Jinan, Shenzhen, and Changsha.[43]

9.2.3 Local–Local Collaborations and M&A Activities

There are a plethora of collaborations, co-operations, and partnerships between local players, which have helped stimulate the cloud industry. In China, Tencent shared a cloud security platform with Kingsoft.[44] There are also M&A activities, which are likely to have long-term positive effects on the cloud.

9.2.4 Local–Foreign Collaborations and M&A Activities

There also collaborations in the BD and cloud industry that involve local and foreign technology firms. Such collaborations have led to the development of various novel, and revolutionary products and services, which have effectively transformed business models and processes, and promoted positive socio-economic changes. Among a high-profile cloud project in China is a collaboration of IBM and China's information services provider Yi Lian Zhong (YLZ). IBM would build a cloud platform for YLZ to connect to networks consisting of citizens, government agencies, social service providers, medical institutions, private and public organizations, and educational institutions. The platform is expected to facilitate the sharing of public resources and information, support service integration, improve government efficiency, and ensure effective administration of citizen services. The services would cover 300 million people.[45]

Similarly, in July 2014, VMware announced that it had teamed up with China Telecom to build hybrid clouds. The CEO of VMware noted that the collaboration would allow China Telecom to sell products under the latter's brand, which has made it easier to do business in the country. Note that China Telecom is a state-owned enterprise (SOE) and is China's biggest CSP.[46] As a

further example, in August 2010, the Japanese electronics company NEC and China's largest IT outsourcing provider Neusoft announced a joint venture (JV) to offer cloud-based services for manufacturers with global export business and SMEs.[47] Another example is Microsoft and China Standard Software Company's (CS2C) collaboration, which involves the development of cloud-based solutions primarily targeted to large clients such as retailers, banks, and government ministries.[48] China is also seeking cloud-related cooperative ventures with manufacturers from Taiwan.[49] Likewise, in October 2011, China's IT leaders held a meeting with those of South Korea and Japan, which explored applications and development trends for cloud computing. Japan's NEC and the Chongqing government have also signed an MoU to help develop Chongqing as a smart city and a cloud hub.[40]

In 2016, Dell signed an agreement deal with the Guizhou-based Wind Cloud to provide cloud services to SMEs. Dell has a plan to invest US$125 billion in China during 2016–2020. Likewise, Microsoft signed a deal with Xiaomi on Microsoft Offices and other cloud-based services.[51]

In early 2016, China Unicom formed a joint venture partnership with the Spanish broadband and telecommunications provider Telefonica to offer BD services in China. The venture entails deploying Telefonica's Smart Steps, which is used to deliver location-based insights by extrapolating and aggregating network data anonymously. Location-based applications in China are expected to be useful for diverse purposes such as urban planning, public security, transportation, and retail and business consultancy.[52]

Huawei has established strategic partnerships with SAP, Accenture, and other companies for joint innovation in BD and cloud computing.[53] As noted in Chapter 8, Huawei and India's Infosys announced a partnership to jointly offer cloud, BD, and communication solutions. The partnership combines Huawei's cloud infrastructure and Infosys' IT service expertise.[54]

9.2.5 Venture Capital (VC) and Other Forms of Foreign Investments

Cloud-related entrepreneurship is also facilitated by the presence of VC firms. In 2011, Intel invested in United Information Technology, a cloud storage products and solutions provider, offering enterprise-class storage products and application software.[55] In early 2012, Intel Capital invested in Beijing Cloud Union, an online gaming company, and Fashion Republic, an Internet fashion photo-sourcing platform.[56] Cloud Union focuses on the design, development, and operation of cloud gaming platforms. With the cloud, it delivers high-quality games.[57]

9.2.6 Standardization Initiatives

A research report released by CCID Consulting in 2010 highlighted the importance of cloud standards, emphasizing that this together with cloud security are among the most urgent issues facing China's cloud computing industry that should be dealt with by the government and other relevant actors.[58] The MIIT has been guiding cloud standardization initiatives. A senior MIIT official noted that "an open attitude" will be adopted in standardization-related actions. The official also noted that Chinese companies will actively take part in the formulation of international cloud standards in order to raise China's concerns.[59] China has participated in various international level initiatives. As noted earlier, China Life and China Unicom are represented in the Open Data Center Alliance.[60] Likewise, in July 2012, the Distributed Management Task Force (DMTF) and the China Electronics Standardization Institute (CESI) announced that they had formed a partnership to drive the adoption of DMTF cloud management standards in China.[61] According to the agreement, the DMTF will work to make its standards meet the requirements outlined by CESI. The CESI, on the other hand, will encourage Chinese companies, universities, and non-profit organizations to adopt DMTF standards which include the Cloud Infrastructure Management Interface (CIMI) and the Open Virtualization Format (OVF) as well as future DMTF standards for Cloud auditing and software license management.

9.3 Drivers of BD and Cloud Industry and Market

Prior research indicates that factors such as consumer preferences, income, availability and costs of input, infrastructures, trade policy, and other types of government regulations, technological economies of scope (a function of prior national experience with previous generations of technology), export orientation of the firms, and market size affect the development of an industry.[62]

9.3.1 Institutional Factors

First, we analyze the roles of formal and informal institutions in the cloud industry. As noted above, institutionalists have emphasized the importance of formal and informal institutions in shaping the developmental pattern of an industry.[63] Institutions are the "rules of the game"[64] and include "formal constraints (rules, laws, constitutions), informal constraints (norms of behavior, conventions, and self-imposed codes of conduct), and their enforcement characteristics."[65] Some specific examples of institutions identified in the prior literature include government regulations, trade policy, the roles of non-governmental organizations such as trade associations and consumer preferences.[66] Scott proposed three institutional pillars: (i) regulative; (ii) normative; and (iii) cognitive.[67] These

pillars relate to "legally sanctioned," "morally governed," and "recognizable, taken-for-granted" behaviors respectively.[68]

9.3.2 Regulative Institutions

Regulative institutions consist of "explicit regulative processes: rule setting, monitoring, and sanctioning activities."[69]

9.3.2.1 State's Mobilization of Resources in BD and the Cloud Industry

A distinguishing mark of China is that the strong state has been capable of mobilizing massive resources in the development of the cloud industry. Government supports have stimulated the diffusion of the cloud. As noted earlier, the 12th Five-Year Plan (2011–2015) has targeted to spend US$308 billion for the telecommunications infrastructures. In August 2013, the State Council released the "Broadband China" initiative, which aims to expand full broadband coverage across the country by 2020. By 2020, the speeds of urban and rural broadband accesses are expected to reach 50 MBPS and 12 MBPS respectively.[70] The broadband coverage in administrative villages is expected to reach 95 percent by 2015 and 98 percent by 2020. The government announced plans to spend US$326 billion on the Broadband China strategy.[71]

There are tax and other incentives for investments in the cloud industry. In October 2011, the National Development and Reform Commission (NDRC), the Ministry of Industry and Information Technology (MIIT), and the Ministry of Finance allocated US$236 million to support indigenous cloud computing. Many local governments, such as Chongqing, Ningxia, and Beijing, have targeted cloud computing and data centers and have provided subsidies to attract businesses in these areas.[72] The Guizhou province has offered tax breaks, grants, and housing allowances in order to attract firms in the BD and the cloud sector.[73]

In 2013, China released plans for building 103 smart cities, districts, and town.[74] As of January 2013, over forty Chinese municipalities had expressed plans to build smart cities. As noted earlier, China also announced an investment to develop a cloud center for high-tech and start-up firms in Chongqing. Likewise, a planned high-profile cloud project is the 100-hectare Jingbei Cloud Valley project at the Miaotan industrial park in the Zhangbei economic development zone of the Hebei province. The government is planning to spend US$1.6 billion on the project. It will have twenty large data centers, power supplying centers, operation and management centers, and a BD center with 500,000 servers.[75]

This does not mean that Chinese policies favor domestic and foreign cloud players equally. The Chinese government has expressed a desire to see the cloud

industry dominated by local companies.[76] It also wants Chinese companies to control a higher share of world cloud markets. To fulfill this desire, it has taken a number of measures. According to the NDRC, the government has viewed cloud computing as a strategic industry.[77] It is worth noting that companies in other strategic sectors are eligible for market protection.

Due to concerns related to national security, currency control, and industrial policy, China has local data server requirements.[78] It is encouraging state-run IT companies such as China Mobile and ZTE to expand BD and cloud services. In May 2014, the National Development and Reform Commission, the Ministry of Industry and Information Technology, and the Ministry of Finance rolled out a funding program designed to help Chinese companies with significant cloud projects meeting certain criteria.[79] China has classified cloud computing as a value-added telecom service (VATS). Under the Chinese regulatory regime, and in accordance with China's WTO commitments, foreign-company ownership is capped at 50 percent in VATS ventures and 49 percent for basic telecom services.[80] This means that foreign CSPs are required to find Chinese partners in order to operate in China. While the central government defines cloud computing as a value-added service, there is no specific "cloud computing" category in the license list of value-added services. Microsoft Office 365 in China is hosted by a Chinese domestic company by license requirement. Other foreign cloud providers such as Amazon, IBM, and SAP have followed similar models.[81]

9.3.2.2 Laws and Policy Related to Security, Privacy, and Control

The cloud-related legal system and enforcement mechanisms are evolving more slowly compared to the technological development.[82] China lacks strong privacy and data protection laws. China's strong state cuts both sides. China's state strategies towards ICTs have been to balance economic modernization and political control.[83] While China's support for the development of the cloud industry is encouraging, it is also using the technology to pursue political goals.

China has allegedly employed cyber-control measures involving the cloud. As noted earlier, the government's cyber-control measures have led to an inability of businesses and consumers to realize the cloud's potential. For instance, China's filtering system makes it difficult or impossible to access cloud services provided by foreign vendors such as Google Docs and Dropbox, and causes significant connectivity speed and capacity reduction. In July 2014, it was reported that Microsoft's OneDrive cloud storage service and Yahoo's Flickr were not accessible from China.[84] A member of China-based anti-censorship site GreatFire.org speculated that these blocks were due to concerns about photo sharing in demonstrations in Hong Kong.[85]

Cyber-control measures have also discouraged foreign investments. Google's 2009 report indicated that it had discovered an attack on its infrastructures that originated in China. In 2008, Google's CEO said that his company would work

with Chinese universities, starting with Tsinghua University, on cloud-related academic programs. The country's unfavorable environment from the security standpoint, however, led to Google's withdrawal from China.

BD and the cloud have helped the Chinese government strengthen its surveillance programs. The many initiatives that are being introduced include the new grid management system. Under this system, grid administrators aggregate reports into a surveillance database. It is then combined with data collected from video cameras and websites. Government agencies analyze that data to detect trends, which can help prevent social unrests before they start. Starting in 2011, the Chinese government has catalogued and divided the provinces into administrative blocks. Within an administrative block, each infrastructural and physical unit (skyscraper, manhole, and park bench) is assigned a fourteen-digit code and entered into the database. In order to gather data and monitor the grid, thousands of employees have been hired, who enter data and manage specific populations. For instance, in the city of Guangzhou, there are about 12,000 employees, who monitor 200 households each.[86]

9.3.3 Normative Institutions

Normative institutions introduce "a prescriptive, evaluative, and obligatory dimension."[87] The basis of compliance in the case of normative institutions derives from professional and social obligations.

9.3.3.1 Special Interest Groups and Non-Government Organizations' Roles

Special interest groups and non-government entities are organized loosely and there is little room for these groups to influence national policymaking in China. We illustrate the China–India differences from the standpoint of security and privacy issues, which are tightly linked to the diffusion of the cloud.[88] Various ongoing efforts and activities initiated by the NASSCOM and the DSCI have played a key role in the cloud's development in India.[89] Trade associations, which are an important component of normative institutions, have been notably absent in China. Nonetheless, there are some encouraging developments. The Chinese government has encouraged the cloud industry to establish a trade association, which can act as a platform to promote cloud development.[90]

9.3.4 Cognitive Institutions

Cognitive institutions are "the shared conceptions that constitute the nature of social reality and the frames through which meaning is made."[91] These are built on the mental maps of decision makers.[92]

9.3.4.1 Price Sensitivity

Unlike in mature economies, SMEs in China tend to be price sensitive and are interested only in a simple online presence. For instance, a survey conducted among Chinese SMEs suggested that many believed that they were paying too much for telecoms services and 24 percent of the respondents were concerned about high prices.[93] Chinese organizations primarily emphasize process improvement, efficiency, and savings, rather than finding innovative ways to make use of the cloud's enormous computing power, speed, and flexibility.[94] Most Chinese organizations' BD and cloud adoption involves a simple and low-cost strategy.

9.3.4.2 Propensity to Outsource

Put simply, the cloud is about outsourcing IT functions. Due to concerns related to data security and overall benefits, businesses are cautious in spending on cloud services.[95] Adopting a cloud model results in a loss of control over these functions. However, for China's state-owned enterprises (SOEs), the ability to control is important.[96] SOEs also exhibit a higher level of concern regarding data security and have a tendency to distrust CSPs.[97] In this regard, a barrier facing the Chinese cloud industry is that large SOEs are reluctant to outsource IT needs and move to the cloud.[98] Indeed, an article published in the *New York Times* suggested that until not long ago, SOEs were not allowed to use outsourced data center services.[99]

9.3.5 Linkages with the Economy

As noted earlier, the developmental pattern of an industry is tightly linked to the forward linkages, backward linkages, and horizontal or inter-sectoral linkages.[100] This section thus examines upstream and downstream linkage effects as well as the horizontal linkages.

9.3.6 Demand-Related Factors

9.3.6.1 BD and Cloud Adoption Propensity of Organizations and Industries

In the healthcare industry, while the investments in the past focused on hardware, a shift is occurring towards software and digital services with the increasing maturity of the industry.[101] The huge market for e-healthcare has created the demand for the cloud. B2B e-commerce, supply chain management, and others have been an important driving force behind the activities of foreign multinationals as well as local firms (Table 9.2). Online gaming, which generated US$6.8 billion in 2011, is an industry that has generated strong forward linkages in China. Gaming

companies are facing intense pressure to transform their processes and business models. The deployment of a cloud platform helped China's second biggest gaming company, Shanda, to enhance the automatic management of the game operation business and reduce data center costs by 80 percent.[102]

Prior researchers have suggested that in most developing economies, government agencies are often the biggest single users of hardware and software.[103] China's SOEs, especially the ones owned by the central government, have increased their cloud investments.[104] The nature of demand in low-tier cities and rural areas is however likely to be different from that in an advanced region.

9.3.6.2 SMEs' Access to Technology

BD and cloud services give SMEs access to technologies they are not able to afford from other sources. According to a Parallels study released in 2011, China's SMEs are likely to go directly to the cloud instead of taking the intermediate step of installing in-house IT solutions. Twenty-eight percent of SMEs had plans to purchase IaaS services by 2014 and 24 percent had plans to adopt the cloud. The study estimated that cloud service market size for the Chinese SMEs would reach US$640 million in 2011. China considers the cloud as an opportunity to provide cost-effective Internet services to SMEs as a component of an ambitious virtualization program.

9.3.7 Input (Backward Linkage)

The development of industries which supply the various ingredients needed for the cloud offer strong backward linkages. In China, R&D activities in the cloud and development of the supercomputing industry have provided backward linkages.

9.3.7.1 Development of Supercomputing Industry and Economies of Agglomeration

The idea in economies of agglomeration is that a large number of firms in related industries benefit from positive externalities by clustering together. Factors such as the presence of multiple suppliers, knowledge spillovers, the availability of intermediate inputs, and labor specialization lead to low costs of production. For instance, by locating close to other firms, they benefit from positive spillovers from investment and economic activities that are already in place. Several mechanisms associated with economies of agglomeration include technology spillovers, advantages of thick markets for specialized skills, and the backward and forward linkages. Users and suppliers of intermediate inputs tend to cluster close to each other because the large market provides greater demand for goods and the supply of inputs.[105]

IDCs and the supercomputer industry provide economies of agglomeration for the cloud industry. As noted above, China has invested heavily in IDCs.[106] In the June 2011 list of the world's top 500 supercomputers, two Chinese computers were represented in the top 10: Tianhe-1A China (No. 2) and Nebulae (No. 4).[107] China's approach to the development of the cloud industry has been to build cloud centers next to regional supercomputing sites. For instance, the Chengdu Cloud Computing Center, which was China's first major commercially operated Cloud Center launched in December 2009, was built by the Chengdu Supercomputer Center and powered by the Dawning 5000 supercomputer. Likewise, the Shenzhen Cloud Computing Center, which completed testing in January 2012, is home to the Nebulae supercomputer. In the same vein, the Changsha Cloud Computing Center which opened in July 2011 is home to the Tianhe-1 supercomputer built by the Chinese National University of Defense Technology (NUDT).[108]

In mid-2016, a Chinese-made supercomputer, Sunway TaihuLight topped the list of the world's most powerful computers. Sunway TaihuLight's capacity is 93 petaflop at its peak, which means that it can perform up to 93,000 trillion calculations per second. It is installed at the National Supercomputing Centre in Wuxi. In the list of the world's 500 most powerful computers, China had 167 computers compared to 165 in the USA. It is the first time since the list began that China has overtaken the USA. Sunway TaihuLight is expected to be used in advanced manufacturing, weather forecasting, and BD analytics.[109]

9.3.7.2 Local Skill and Technological Base

Foreign as well as local firms are involved in BD- and cloud-related R&D activities. ZTE's 10,000 m^2 global cloud center in Nanjing had about 3,000 R&D staff in 2011. As noted above, China Telecom and Cambridge University have teamed up to conduct research involving the M-health cloud. IBM's Shanghai R&D facility has the cloud as a primary area. As noted earlier, IBM is also working on a research project, which involves statistical analyses to assess TCM treatments' effectiveness. Overall, 490 of world's top 500 companies have established over 1,160 R&D centers in China. An issue is the availability of skilled manpower. Companies have faced difficulty in finding people with the appropriate skills to operate cloud services.[110]

9.3.8 Structures of Related Industries (Horizontal Linkage)

An inter-sectoral linkage is said to exist between two economic sectors if events in one provide a stimulus to another. For instance, a higher ICT penetration rate and bandwidth availability may lead to higher demands of cloud-related products and services. Conversely, ICT users are more likely to enjoy higher benefits from the cloud.

9.3.8.1 ICT Penetration

The availability of a web-connected computer, cellphone, or other devices is a prerequisite to benefit from the cloud. The role of the cloud is to change the delivery, pricing, and consumption of the IT functionality.[111] The cloud can help leverage existing ICT investments, systems, and infrastructures. High and rapidly growing cellular penetration provide strong horizontal linkages due to the popularity of mobile clouds. While the majority of China's population has no PC, by mid-2015, China had about 1.3 billion mobile phone users, which is close to 100 percent of the population.[112]

9.3.8.2 Bandwidth Availability

The basic idea in the cloud model is that computation and storage concentrate on the clouds and high-performance machines are linked by high-bandwidth connections to manage resources.[113] High bandwidth is thus required for a better and effective utilization of existing resources on the clouds. In 2011, China added 30 million fixed broadband subscriptions, which was about half of the total subscriptions added worldwide. The country's fixed broadband penetration reached 12 percent in 2011.[114] At the same time, as in most developing countries, low bandwidth has been the most glaring shortcoming in rural areas, which has hampered the cloud's growth. The Broadband China initiative is likely to address this shortcoming.

9.4 Discussion and Concluding Comments

The overriding reality is that only a small segment of the economy is currently benefiting from the cloud. Since most Chinese firms have not yet connected to the Internet, the cloud's biggest impacts on the country's economy have not yet materialized.[115] That is, BD and the cloud is in the infant stage of development and cloud-based innovations and business models are yet far from inclusive of SMEs. However, as economic (e.g., connectivity and affordability) and institutional factors improve, the cloud may certainly gain momentum and holds a promise to bridge the digital divide. On the upside, China is less likely to face barriers related to privacy and security regulations.

The entry of foreign CSPs has forced local firms to be more competitive. For instance, just before Amazon's announcement of entry into the Chinese market, the cloud division of Alibaba, Aliyun, said that it would cut the price of its services by up to 35 percent.[116] Chinese firms' low-cost strategy and experiences in serving the home market may allow them to develop value-creating strategies and realize a significant share in the global cloud market, especially in the developing world. At the same time, while Chinese IT companies have undertaken successful entrepreneurial activities on the home front, they may

face barriers in foreign countries. Cloud providers from China might experience a negative country-of-origin effect. As noted above, the institutional environment in China cannot guarantee data security and privacy. These concerns further increase if one takes into consideration the possibility of government control of China-based CSPs.

The above discussion also leads to some guidance for foreign CSPs in navigating China's tricky business landscape. As discussed above, global CSPs face a number of challenges in China. They include the underdeveloped ICT infrastructure, a complex regulatory environment, skill unavailability, and China's geopolitical tensions. Moreover, China has expressed a high degree of suspicion and distrust towards foreign CSPs. IT companies such as IBM and Cisco have reported declines in their China sales after revelations of alleged US spying. Foreign and local CSPs vary considerably in their cloud-related capabilities and focus on different market segments. According to a Gartner analyst, most Chinese CSPs have the capability to provide cloud services to SMEs or start-up companies. Global players such as AWS, on the other hand, have offerings appropriate for large enterprises or government organizations.[117] According to an analyst at Forrester Research in Beijing, the key advantages of foreign CSPs concern the richness of product offerings, quality, and experience in servicing large-scale clients. For one thing, SOEs are not potential customers for foreign CSPs. SOEs are often expected to sign deals with Chinese CSPs. Foreign companies are required to take measures to avoid hosting illegal contents (e.g., pornography and politically sensitive speech). They also need to be prepared to deal with the government's overly forceful measures, such as occasional "lockdown." On some occasions, IT companies are not allowed to move hardware to or from IDCs. Such lockdowns lasted for over three weeks in early 2014, when a big political meeting was being held in Beijing.[118]

Economies of scales have undoubtedly played a major role in attracting global and local players in the Chinese cloud industry. The breadth and depth of cloud offerings thus would continue to expand. Smaller developing economies lack some of the favorable conditions enjoyed by China and are less attractive markets for cloud suppliers, and thus face more problems in the development of the cloud industry.

Chinese policy makers have recognized the opportunity to tap this technology to slip into a higher gear. Due to China's strong state and weak civil society, the private sector's roles have been relatively less significant. China has also shown a willingness to form an astonishing alliance with its traditional rival, Chinese Taipei, and relax cyber-control measures. While government purchases of products and services are expected to drive cloud diffusion, they would favor products that incorporate high levels of domestically developed technology.

Other developing economies are likely to benefit from the lesson and experience of China's cloud industry. Especially relevant and important in this regard are Chinese companies' expertise and experience in healthcare IT. For instance,

Huawei built China's first Healthcare Cloud deployed in the Zhabei District. Chinese companies such as Huawei and Alibaba can easily adapt the business models used in their domestic markets. Their capability to deliver value for money in the domestic market is likely to be an important source of their competitive advantage to operate in other developing economies.

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10

BRAZIL

10.1 Introduction

Brazil has emerged as a key global cloud market. According to a survey released by Cisco in 2010, the adoption of cloud computing in Brazilian companies had surpassed the levels in Germany and the USA.[1] Frost & Sullivan's survey indicated that the size of the Brazilian cloud market was US$328.8 million in 2013, which is expected to reach US$1.11 billion in 2017.[2] Likewise, the ICT consultancy firm IDC predicted that the Brazilian cloud market would grow at a 74.3 percent CAGR (Compound Annual Growth Rate) during 2013–2015 and would reach US$798 million in 2015. According to IDC, Brazil accounts for over half of the Latin American cloud market.[3] The country also accounts for 40 percent of all Latin America's data centers[4] and over three-quarters of Latin America's bandwidth.[5] The Brazilian data center networking market was estimated at US$0.5 billion in 2013, which is expected to reach US$1.1 billion by 2018.[6] Likewise, as of 2013, Brazil had twenty-three Internet exchange points (IXPs), which put the country second only to the USA in the number of IXPs. Note that IXPs are the locations where Internet bandwidth is produced and about half of all countries produce no Internet bandwidth domestically.[7]

Some Brazilian companies have developed innovative BD and cloud-based solutions, taking into account unique local problems and opportunities. For instance, the cloud has promoted a more efficient utilization of resources in households. Brazil's Gol Group teamed up with the telephone companies Telefonica and Vivo, the newspapers *O Estado de São Paulo* and *O Globo*, and the computer manufacturer Itautec to launch Nuvem de Livros (cloud of Books) in September 2013. When Nuvem de Livros was launched on October 1, 2013, it offered 3,000 titles from some twenty-five publishing houses and 1,500 video

classes, which were provided by the Roberto Marinho Foundation. The books can be read on computers, digital readers, tablets, and cellphones. Gol's proprietary DRM prevents unauthorized downloading. While Nuvem de Livros was designed primarily for schools, it also offers content for the whole family. Since the average size of an apartment is forty-five square meters, most lack the storage space for books.[8] Nuvem de Livros is thus a perfect solution for most Brazilian households.

The Brazilian Forest Service uses a traceability and information management system to track trees as they are logged and sawn into timber. It also uses remote sensing data to monitor forest management.[9] The Rio de Janeiro, Brazil-based, BVRio's Responsible Timber Exchange uses BD to assess potential sellers' compliance with US and European restrictions on illegal wood imports. BVRio's database uses official documentation such as logging permits and sawmill operating licenses, the legal record of forest owners, loggers, and the forest engineers involved in a shipment to assess the risk of irregularities. Other categories of data include the average volumes of a given species of tree normally cut under a standard permit and satellite images. In the future, it will also employ field checks.[10] As of mid-2016, Piracicaba, a São Paulo-based civil non-profit association, the Institute of Agricultural, and Forest Management and Certification (The Instituto de Manejo e Certificação Florestal e Agrícola: IMAFLORA) have been in the process of creating a digital platform to organize information related to the production, transportation, and transactions of timbers in order to increase transparency and governance capacity.[11]

The Brazilian cloud computing industry and market possess unique and idiosyncratic features, which are associated with the country's economic, political, cultural, and social factors. Brazil is among the major economies with some of the strongest protectionist policies in the cloud sector. For instance, the Brazilian government has discontinued the use of foreign companies' cloud applications such as Microsoft Outlook and developed its own system to replace them. In general, surveys and anecdotes have indicated that cloud security is likely to be especially salient, and perhaps contentious, for government agencies and SOEs in Brazil.

Likewise, the key ingredients of the cloud industry and market are heterogeneously developed in the country. For instance, on the plus side, Brazilian firms have exhibited a higher propensity to adopt the cloud compared to a number of industrialized countries. On the other hand, the Brazilian cloud industry has faced major difficulties and challenges on key issues such as skills availability and the costs of data centers and networks.

10.2 Key Features of the Brazilian BD and Cloud Industry and Market

As noted earlier, Brazilian firms are known to have a high propensity to adopt modern ICTs. In 2013, over half of Brazilian enterprises were reported to have

placed online orders.[12] Brazilian firms have also exhibited a strong propensity to adopt cloud services. According to a survey conducted by Frost & Sullivan, 66 percent of Brazilian CIOs planned to invest in cloud computing in 2012.[13] According to a survey conducted by the business to business market research company, Coleman Parkes Research, Brazilian SMEs had a cloud adoption rate of 77 percent, which was the highest among the ten countries surveyed. The survey also found that most SMEs in Brazil used only entry-level cloud services, which included free storage and back-up services such as Dropbox and Google Drive (87 percent), and paid services such as computer networks (54 percent).[14] Frost & Sullivan's study also estimated that the Brazilian BD market will reach US$578 million in 2016.[15]

BD and cloud solution adoptions in Brazil are being driven by telecom operators and the financial industry,[16] as well as by firms in retail and health care.[17] In 2015, the credit information provider Experian, also known as Serasa Experian, announced a plan to invest US$8.2 million in BD initiatives in Brazil over the next five years. The plan includes a lab in São Paulo dedicated to data-related products and services. Brazil is Experian's third biggest market in terms of revenue, behind the USA and the UK.[18]

In general, cloud adoption rates have been the fastest among verticals, which offer specialized products to an industry, trade, profession, or other group of customers.[19] The cloud has also been attractive among e-commerce firms, which exhibit big seasonal variations in demands.[20] Likewise, SMEs are attracted towards IaaS services (e.g., storage and back-up) to manage IT needs with their growth.[21]

The huge and rapidly growing Brazilian cloud market has attracted foreign as well as local CSPs. AWS expanded the cloud to South America in 2011 by establishing data center infrastructure in São Paulo. In 2014, it added a second cloud center in Rio de Janeiro. Microsoft, Cisco, Equinix, Dimension Data, Verizon Terremark, and cloud and managed services provider Latisys are also present in Brazil.[22] In 2013, the local firm Capgemini and EMC announced a plan to work collaboratively to deliver next-generation cloud solutions to businesses.[23]

Among the many benefits of the cloud, cost saving has been the main attracting feature for Brazilian firms. In a global survey of IT decision makers on cloud computing usage trends conducted by the research company TNS, 92 percent of Brazilian organizations reported saving money, which was the highest proportion among the eight countries included in the survey: Australia, Brazil, France, Germany, Japan, Singapore, the UK, and the USA.[24]

According Frost & Sullivan, Brazil and other economies in the Latin American and Caribbean region were less affected by the 2008 global financial crisis. As a result, cloud-computing investments did not suffer in these economies. In recent years, the growing demand for flexibility and scalability has driven the cloud market in these economies.[25] Moreover, Brazil came under tremendous pressure to develop IT infrastructure and strengthen policies in order to successfully host the 2014 FIFA's Soccer World Cup.

Brazil also came under tremendous pressure to develop IT infrastructures for the Olympics in 2016. The resulting developments are having a positive impact on the Brazilian BD and cloud industry and market.[26] In order to support the FIFA's Soccer World Cup event, Brazil earmarked over US$12 billion in 2012 in IT infrastructure development funds.[27] Thanks to these initiatives and others, in 2014, Brazil ranked seventh in terms of global IT investment, following the USA, Japan, China, UK, Germany, and France.[28]

Brazilian and foreign firms involved in the 2014 FIFA's Soccer World Cup exhibited a sophisticated deployment of the cloud. For instance, fans could view, vote, and bet on a variety of devices. The chief executive of the football app developer Onefootball noted that in order to cope with high digital traffic volumes, a huge content management system was built and the AWS was deployed for load balancing.[29] The related knowledge, skills, and experiences are likely to play a key role in strengthening the Brazilian cloud ecosystem.

Government agencies and state-owned enterprises (SOEs) in Brazil have expressed serious concerns and reservations regarding cloud security. Brazil's IT policy secretary discussed the possibility that the Brazilian government may store sensitive data locally rather than in the cloud.[30] Likewise, Marcel José Kaskus, the IT software solutions general manager of Brazil's state-owned oil giant Petrobras, noted that the company made some use of private clouds but not public clouds. He expressed concerns related to security of clouds. In general, Petrobras prefers to deploy proprietary systems and Brazilian-developed software.[31]

10.3 Economic and Infrastructural Factors Affecting the Development of the Brazilian Cloud Industry and Market

The World Economic Forum's (WEF) Global Information Technology Report 2012 provides useful insights into the economic and infrastructural situations facing the Brazilian cloud industry and market. Overall, Brazil ranked sixty-fifth (out of 142 economies analyzed) in the WEF's Networked Readiness Index. The country, however, ranked thirty-third in the benefits from strong levels of business ICT usage, third in levels of technological capacity, twenty-ninth in the performance of ICT-enabled innovations, and thirty-fourth in the efficiency of processes.[32] Likewise, Brazil is the best-performing economy in Latin America in terms of the maturity of fiber infrastructure and connectivity with the USA.[33]

High networking and related costs have exerted a major negative effect on the Brazilian cloud industry and market. The high costs are especially pertinent in public or hybrid models.[34] The labor costs in Brazil are the highest in Latin America and higher than most emerging economies.[35] Likewise, during 2004–2014, the costs of industrial electricity doubled and that of natural gas increased by 60 percent.[36] Despite the abundance of hydro power and the low

cost of generation, electricity is subject to price fluctuation and there is a shortage of supply in during the drought years.[37] According to a survey of twenty-six countries conducted by FIRJAN System, which represents the industrial sectors in Rio de Janeiro, Brazil's energy cost was the highest among the BRIC economies and the fourth highest worldwide.[38]

According to 451 Research's Cloud Price Index report, Latin America is the world's most expensive region to use the public cloud. The price of the cloud in the region is reported to be 38 percent higher than in the USA. The region arguably has the most limited selection of CSPs.[39] Brazil is probably the most expensive Latin American countries for the cloud. The land for building data centers and hardware related to the cloud is also expensive.[40] According to the BRASSCOM, the average cost for establishing a data center in Brazil is about US$61 million and the annual maintenance costs average US$100 million compared to US$43 million and US$43 million respectively in the USA.[41]

The lack of affordability has also been a major hindrance. Before the PNBL implementation, for instance, an average Brazilian household spent about 4.5 percent of their income on broadband services compared to the average of 0.5 percent for developed countries.[42] In the WEF's Global Information Technology Report 2016, Brazil ranked eighty-seventh in terms of mobile cellular tariffs. As of early 2014, a 1 MBPS connection cost about US$25 in Brazil compared to US$0.63 in Sweden and US$0.27 in Japan.[43] The tax rate for bandwidth services is 40 percent in Brazil compared to 5 percent in Japan.[44] It is also worth noting that the Japanese government has provided interest-free loans to broadband operators and the Swedish government covered half of the rural broadband construction costs.[45]

Another important barrier has centered on the lack of relevant skills. In the WEF's Global Information Technology Report 2012, Brazil ranked eighty-sixth in terms of skill availability.[46] According to the Brazilian Agency for Promotion and Export of Software (Softex), the Brazilian IT sector employed 600,000 people in 2011. The Softex estimated a shortage of about 200,000 skilled professionals in 2013 in the country.[47]

A 2012 report by the law firm Cushman and Wakefield and the engineering consultancy Hurley Palmer Flatt noted that high energy prices and shortage of skilled manpower increase risks in building data centers in Brazil.[48] Some global CSPs have raised concerns related to the high costs of establishing data centers and the difficulty of finding local talents. In 2012, Google announced its plan to open its first Latin America data center in Chile rather than in Brazil. Chile's reliable infrastructure and skilled workforce played a key role in the decision.[49]

Finally, there is a wide rural–urban gap in the development and availability of ICT infrastructures. For instance, broadband Internet is not easily available in smaller towns and rural areas.[50] The majority of data centers have been built in the region of São Paulo, which is South America's largest data center market.[51] São Paulo is estimated to account for 50 percent of the country's data center capacity.[52]

10.4 Institutional- and Policy-Related Factors Affecting the Development of the Brazilian BD and Cloud Industry and Market

Regarding institutional- and policy-related factors from the cloud's standpoint, it is notable and encouraging that highly motivated federal and local governments have focused on policies aimed at transforming Brazil into a world-class data center hub. In 2012, the federal government announced a plan to hire a consulting firm to study how Brazil's competitiveness on the cloud front can be increased.[53] The government has also taken initiatives to facilitate the diffusion of the cloud and related technologies. The national broadband plan, Plano National de Banda Larga (PNBL), which is the federal government initiative to provide broadband access to low-income population, deserves mention.[54] As of early 2012, the number of Brazilian municipalities covered by the PNBL reached 692. The goal has been to extend broadband coverage to 4,424 cities by 2017.[55]

Brazil's official position on cloud computing has been to provide "an adequate regulatory environment—which doesn't isolate the country, but offers security to citizens, enterprises and the government."[56] The country views that these measures could help the growth of the Brazilian cloud industry and market, attract foreign investments, and support the development of Brazilian CSPs and their international expansions. Policy measures have also been undertaken to protect consumer privacy. An article published in the *New York Times* explained that the new Internet Bill of Rights requires technology companies to obtain users' permission before their data is shared with online advertisers and marketers.[57]

However, among foreign ICT companies, there is widespread and growing disenchantment with the adequacy of the Brazilian regulatory system for the cloud industry. A big concern is that Brazil lacks an appropriate framework for the development of ICT standards, and that it gives domestic service providers preferential treatment in public procurement.[58]

There are also concerns about the frequent changes in regulatory and compliance requirements. For example, in 2013, the Brazilian government raised import duties for uninterruptible power supplies (UPS) coming outside Mercosur countries (Brazil, Argentina, Venezuela, Bolivia, Paraguay, and Uruguay) from 16 to 20 percent.[59]

Of greatest relevance here is the Business Software Alliance's (BSA) Global Cloud Computing Scorecard which considers factors such as Data Privacy, Security, Cybercrime, Intellectual Property Rights, Support for Industry-Led Standards, and International Harmonization of Rules Promoting Free Trade and ICT Readiness. In the BSA's 2012 ranking of twenty-four countries' cloud environments, Brazil finished last. In the 2013 BSA Scorecard, Brazil improved slightly and ranked twenty-second of the twenty-four economies considered.[60]

The rank remained unchanged at #22 in 2016. In the 2013 Scorecard, Brazil ranked at the bottom in terms of international harmonization.[61] The lack of harmonization of international rules is likely to hinder a smooth flow of data between CSPs in different countries. Likewise, an inappropriate standardization may act as a barrier to ensure data portability. Similarly, Brazil has not signed the WIPO Copyright Treaty, which means a lack of strong regulations to protect a new technology.

The NSA scandal marked an important turning point in Brazil's cloud policy and strategy. The then Brazilian President Rousseff has been one of the most vocal critics of the PRISM program. In order to avoid possible security risks and compromises, Brazil is trying to keep itself away from US-based data centers, equipment, and technologies. In September 2013, Rousseff asked the Congress to introduce regulations to require foreign companies to store data generated inside the country on local servers.[62]

The proposed regulation, however, faced strong resistance and criticism from foreign technology companies. Foreign companies warned that the requirement of data localization may lead to closure and divestment of their facilities and operations. For instance, Google criticized and opposed the legislation on the grounds that data is likely to be more secure if it is stored in multiple locations. The company argued that storing data in one location slows down the services and increases customer inconvenience. Google's director of law enforcement and information security Richard Salgado argued that Brazil's proposed law to require all the data of Brazilian citizens and companies to be stored within the country would be too difficult to comply with and noted that Google "could be barred from doing business" in Brazil.[63]

In October 2013, forty-seven organizations representing diverse industries worldwide sent a letter to selected Brazilian Congress members pointing out several unintended consequences of the proposed data center localization. Their criticism focused on four main points: decreased security (data security depends on how data is protected and a focus on physical location may distract from the reality), higher costs (not being able to enjoy economies of scale, which would increase costs for end-users), decreased competitiveness (isolation from the world's innovative and efficient cloud services and strong computing power around the world), and harm to consumers (denial of cloud services available around the world).

Due to these criticisms and other challenges, when the Internet Bill of Rights known as "Marco Civil da Internet" was passed by the Brazilian Senate in April 2014, the government agreed to withdraw a provision, which would have required foreign Internet companies to host the data of Brazilians within the country.[64] The withdrawal of the provision was necessary in order to get the opposition support. There was a fear among many Brazilian politicians that data localization may negatively affect Brazil's national competitiveness.

Nonetheless, according to the new provisions, CSPs may not disclose log data and private communications without a Brazilian court order. CSPs are

required to follow the new law even if the data is stored outside its jurisdiction if collection, storage, or processing of data takes place in Brazil or one end of a personal communication is in Brazil.[65] Due to the new regulations, foreign CSPs serving the Brazilian market may face conflicting demands and pressures. For instance, if Brazilian consumers' data is stored in the USA, the Electronic Communications Privacy Act (ECPA) requires user consent to disclose the content to a foreign (in this case, Brazilian) government. Moreover, if data stored in the USA is subject to the Brazilian law requiring that data can be only disclosed pursuant to an order of a Brazilian court, disclosing the content to the US government may violate the Brazilian law.

Overall, there are some signs that Brazilian cloud regulations are working against foreign IT firms. For instance, Microsoft lost the government of Brazil as its customer. Brazil announced plans to discontinue the use of Microsoft Outlook and replace it with its own email system that uses Brazilian data centers.[66] Brazil has replaced the Microsoft Outlook by a custom-made system, Expresso V3. Expresso V3 was developed by the Federal Service of Data Processing (SERPRO), which is a company that offers Information Technology and Communication Services to the public sector. Expresso V3 runs on the cloud platform maintained by the SERPRO and aims to protect official emails from all types of surveillance. As of September 2013, SERPRO had spent about US$3.9 million to purchase network equipment, new servers, security systems, and a data link of 10 GBPS to connect the organization's three data centers.[67] Likewise, in April 2014, the Ministry of Defense started the installation of a secure digital communication network for federal government offices. The system, which was expected to be fully installed throughout federal government offices by the end of 2014, includes instant messaging, web conferencing, and other functions.[68]

The above said, there are a number of encouraging signs. For instance, Brazil was among the countries showing the most improvement in the infrastructure score in 2013. Brazil is also making significant progress in combating software piracy. According to Business Software Alliance (BSA), the proportion of software products without original licenses decreased from about 59 percent in 2007 to about 50 percent in 2014.[69] A related point is that the diffusion of more accessible cloud tools such as Google Docs could help reduce piracy.

10.5 Discussion and Concluding Comments

Brazil has made a remarkable progress on the cloud front in a short time. A complete understanding the country's emergent cloud market necessitates a consideration of the interplay of contradictory forces that are working to shape the market. For instance, while the government has exhibited an exceptionally high degree of motivation to develop Brazil as a global cloud hub, it has also expressed a high degree of suspicion and distrust of foreign CSPs. These factors

are likely to play an important role in influencing the costs, quality, and availability of cloud-related services. Some experts have noted the cloud security-related measures announced following revelation of the NSA monitoring scandal are more emotional, rather than rational, responses and will do little to strengthen cybersecurity. They also argue that Brazil's protectionist measures work against the economics of cloud computing. Efforts are also needed to promote openness and interoperability. It is also important for the government to work with the industry to develop standards and minimize conflicting legal obligations on CSPs.

Regarding data localization, a point that needs to be emphasized is users' preferences. Observers note that users in Brazil prefer to keep their data locally due to fear of interception by foreign intelligence agencies such the US NSA.[70]

Despite the attractiveness of the Brazilian cloud market, the country lacks international competitiveness in the development of data centers. Likewise, as noted earlier, the digital divide between big cities and rural areas has been a key concern. In this regard, the infrastructure development funds that were allocated to the 2014 FIFA's Soccer World Cup event helped bridge the rural–urban divide. The matches were played in twelve Brazilian cities. Likewise, initiatives such as PNBL are likely to contribute to a further development of the Brazilian cloud industry and market, and bridge the rural–urban divide. For instance, PNBL has promised lower prices for broadband services.

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PART IV

Lessons Learned, Implications, and the Way Forward

11

DISCUSSION, IMPLICATIONS, AND CONCLUSION

11.1 Introduction

The analysis provided in the earlier chapters of this book suggests that BD and the cloud have a disruptive and transformative potential for developing countries. It has pointed to a large number of applications that in different ways can support the implementation of many Sustainable Development Goals. At the same time, benefits cannot be taken for granted and various risks will also emerge as more and more economic activities shift online. For developing countries to seize the full benefits from BD and the cloud, they therefore need to address a range of policy challenges, and effective support will be required from the international community.

The development and deployment of BD and cloud computing solutions across key industries and economies in the global South show strikingly diverse patterns. Some organizations such as China's Alibaba have developed and deployed sophisticated and well-engineered BD and cloud systems. However, the majority of the uses in the developing world need low-cost solutions that fit their specific needs as well as economic and infrastructural contexts.

The uses of BD and the cloud in most developing countries have so far focused on only a few economic sectors. Put differently, the adoption of BD and cloud tools in these economies is far from widespread and from being effectively integrated into the broader economic sectors. For instance, in China, the three Internet giants Alibaba, Baidu, and Tencent are believed to have the same level of caliber and skills in BD as Western technology companies. However, many of China's other industries are lagging behind. Observers have noted that telecommunications, banks, governments, and medical institutions are far from harnessing the full power of BD.[1]

The integration of BD, the cloud, and mobile computing technologies offers particular promise for facilitating economic productivity and social development in developing economies. The Mifapro and other cases highlighted in this book show that they can play a key role in promoting the well-being of disadvantaged groups, improve the functioning of markets for agricultural produce, and affect the allocation of resources. Enhanced availability of information can also help to better evaluate the risks and uncertainties for various market participants.

11.2 BD and the Cloud in Developing Countries in Relation to Innovation and Technological Progress

A number of business and government policy initiatives directed towards improving innovation performance in BD and the cloud areas have been launched by the private sector and national governments in developing economies. As a result some emerging economies are already evolving as hotbeds of innovation in these areas, perhaps most notably in China.

But excellence is also visible elsewhere. Some SSA-based firms are impressive in their ability to bring together innovations involving local capacity building. In a 2011 survey of the world's top experts on Internet-related innovations, 7 percent viewed Africa as "the most innovative place for Internet-related technology." The corresponding proportions for other regions and economies were: Europe: 4 percent; China: 4 percent; India: 7 percent; and the Pacific Rim: 5 percent. The experts viewed Africa's Internet-related innovations as: "On-the-ground solutions designed by communities for communities."[2] India's relatively poor R&D and innovation performance has led some experts to argue that entrepreneurial activities in the Indian ICT and offshoring industry have a "hollow ring." An *Economist* article notes: "India makes drugs, but copies almost all of the compounds; it writes software, but rarely owns the result … [it has] flourished, but mostly on the back of other countries' technology."[3] In view of the prominent roles of some Indian technology firms in the global arena, they have showed less impressive performance in generating innovative solutions to solve local problems. This points to a general observation made by the United Nations, that developing countries should give due attention to leverage their indigenous ICT and especially software industries to serve local development needs and demands.[4]

Foreign multinationals are also helping to stimulate and facilitate innovation in developing countries. For example, IBM built its forty-first global Innovation Center in Kenya's Nairobi in 2013, which is first such Center in East Africa. A key focus of the Center is on mobile and cloud technologies to solve local and global challenges, such as traffic congestion and better energy management.[5] As of early 2016, IBM Research Africa had about thirty-five specialists in Kenya in diverse fields such as computer sciences, engineering, and environmental

science. In addition, the Nairobi lab had thirty-five software developers and trainees from local universities.[6]

Innovations in privacy and security are focusing on smartphones and wearable devices. For instance, HID Global, which manufactures access control cards that are used to open doors in offices and hotel rooms, has teamed up with chipmaker NXP Semiconductors to expand the technology to work with smartphones and wearables (e.g., Apple Watches and Android Wear). Due to privacy concerns, HID's platform will allow individuals to decide the amount of information shared. For example, a police officer can be given access to more detailed data than a liquor store worker that merely wants to verify a customer's age. The owner sends it from his/her smartphone. The company is pushing several BD projects including digitization of Nigeria's entire vehicle ownership system. The goal is to put the country's more than fifty million cars onto a database that is accessible by a smartphone.[7]

BD- and cloud-based tools such as Sproxil's MPA system can realize economies of scope by providing services in other sectors. For instance, manufacturers have started using Sproxil's MPA system to eliminate counterfeit products. A survey conducted by Schneider Electric showed that counterfeit electrical products account for 40–80 percent of their markets in African countries. Some of the most counterfeited electrical products include sockets, cables, switches, and extension cords. In 2012, Nigeria's hair- and skin-care product manufacturers and the Swiss company O'tentika started a collaboration with Sproxil,[8] and East African Cables also employs Sproxil's systems to fight counterfeits.[9]

11.3 Challenges and Obstacles Associated with BD and the Cloud

There are a number of challenges to overcome in the deployment of BD and the cloud in the developing world.

11.3.1 Changing Skills Requirement

A major concern for harnessing the full potential of BD and the cloud is the lack of relevant skills, knowledge, expertise, and experience. In a survey conducted by the online recruitment website Monster.com, 68 percent of employers in the Middle East and India believed that it was "extremely difficult" or "difficult" to hire talent for technology.[10]

In another survey by Accenture among Indian enterprises, 53 percent of the respondents cited the lack of talent to be a key challenge in BD and cloud deployment.[11] McKinsey estimates that India will need 200,000 data scientists in the near future.[12] Snapdeal.com said that the company has not been able to find the coders and other BD manpower it needs. The company recognizes the need

for world-wide recruitment for experienced programmers dealing with BD, cloud computing, and the software for interacting with customers and suppliers. Snapdeal was hiring cloud specialists from the United States as well as considering establishing a software development center in the USA, and buying firms there in order to capture the needed manpower.[13] According to the Internet & Mobile Association of India, there were 50,000–70,000 mobile developers in India in 2015. It is estimated that twenty million developers will be needed by 2020.[14]

Skill deficits for BD and the cloud often reflect broader problems of low educational quality, achievement, and standards. For instance, the inability of Vietnamese universities to train the next generation of highly-skilled workers has been a significant roadblock in this context.[15] Likewise, according to the UNESCO, only 6 percent of Africa's young people are enrolled in higher educational institutions compared to the global average of 26 percent.[16] A large number of organizations in Africa have had limited experience in data cleansing or standardization. There is thus a general lack of skills in the advanced techniques and technologies required for BD.[17] South Arica is estimated to require at least 200 data scientists to participate in the SKA alone.[18]

11.3.2 High Data Creation and Data Access Costs

High costs are a major obstacle for consumers to engage in activities that generate data. Consider South Africa. Consumers with an income of R3,000 (US$225) a month, which is significantly above the national minimum wage, needed to work around eighteen hours in order to afford a 500 MB data plan. Thus, even if consumers can afford smartphones, they often cannot afford to use them other than like "dumb" phones.[19] At the 2016 price level, only a quarter of Indonesians and 22 percent of Chinese could afford data consumption of 500 MB per month.[20] From a pure cost perspective, in order to get everyone online, data prices need to fall by 90 percent or more. As of 2016, developing economies had only seventy-seven Internet exchange points compared to 134 in the developed economies. North America with a population of 350 million had eighty-five IXPs compared to eight in South Asia with a population of 1,760 million.[21]

11.3.3 Resistance from Vested Interests

Resistance from some powerful actors, who derive their market position and authority by controlling or selectively sharing access to information, can be a huge obstacle. Increasing access to data and information can threaten such actors' current sense of power and authority. Consider the lack of disclosure of data related to soil pollution in China. Between 2006 and 2010, China's Ministry of Environmental Protection (MEP) and the Ministry of Land and Resources

(MLR) conducted surveys of soil pollution in China. A 2014 report indicated that 16 percent of about 10,000 testing points failed to meet the specified standards. Analysts argued that there are significantly more polluted sites than the testing points covered by the surveys. One estimate suggested that China has between 300,000 and 500,000 polluted sites, or thirty to fifty times higher than the number of testing points covered in the surveys.[22]

11.4 Implications for Technology Marketers

There are a number of implications for technology marketers and technology entrepreneurs.

11.4.1 Involving Relevant Stakeholders

It is important to identify broader relevant stakeholders, especially users, and increase their involvement in the design process. For instance, the experiences of mobile cloud-based e-learning in SSA economies indicate that teachers can play a crucial role in designing, developing, and implementing education-related technologies.[23] Likewise, in the development of healthcare applications, collaboration with end-users such as health facility staff, community health workers, or community leaders is essential to inform program design and improve implementation in the local context.[24]

11.4.2 Considering Technologically Unsavvy and Less Savvy Users

In formulating policies and designing BD- and cloud-based mobile computing solutions tailored to the needs of developing countries, it is helpful to consider the extent to which end-users are technologically savvy or less savvy. The cloud-based systems used in developing countries need to be technically as simple as possible. In the MADEX system, for instance, pressing the send button is the only action that is required to be taken by midwives in order to send monthly reports.[25] Likewise, an entrepreneur making a sale using Lula is required to press only a few buttons.[26]

11.4.3 Involvement and Mobilization of Local Talent and Resources

The successful initiatives in BD- and cloud-based mobile computing solutions in developing countries are mainly indigenously triggered, albeit often with involvement of foreign companies. They are also oriented towards the active involvement of local communities and the mobilization of local entrepreneurial resources. For instance, Nomanini's success can be largely attributed to the

founders' expertise in ICTs and an in-depth and intimate understanding of the African market. The founders noted that Lula is a uniquely "South African born-and-bred solution" that targets the needs and interests of the local population.[27]

It was a team of programmers in Kenya who developed the EpiSurveyor system.[28] The Farmforce platform was developed in 2011 by a team based in Switzerland with inputs from a team based in Kenya.[29] Likewise, Kenya-based Safaricom in partnership with the local organization Green Dreams envisioned and developed the iCow system.

In 2011, Safaricom launched Safaricom Cloud, arguably Africa's "largest native cloud deployment."[30] It started hosting Mpesa mobile money services locally and launched new cloud offerings, including hosting platforms for government agencies and corporations. As of 2011, the company had invested US$150 million in clouds and announced plans to invest additional US$200 million.[31] Safaricom teamed up with Cisco for storage facilities, EMC for security, and Seven Seas Technology for training managers.

11.4.4 Consideration of Affordability, Open Source, and Other Related Aspects

For global IT providers, affordability and customization to meet the local requirements will be a key consideration to compete in developing countries. Regarding the benefits of Android phones over low-cost feature phones, the director of ICT innovation at the Grameen Foundation noted that the open source nature of Android allowed Grameen to hire its own developers to customize the phones. The customization enabled an improved use of power and to make applications usable when the phones are not connected to a network.[32]

A related point is that BD- and cloud-related products and services offered in developing markets must recognize—at least in the short run—the local technological reality, such as low bandwidth and mobile-driven digitization. Finally, the diffusion of BD- and cloud-based mobile computing solutions is an issue that has policy implications for enhancing agricultural productivity and food security, creating rural employment and reducing poverty.

11.4.5 BD- and Cloud-Related Innovations from the South for the South

Some innovations in BD- and cloud-based mobile computing are from the South (developing countries) for the South, an encouraging trend in the new geography of global innovations. As discussed earlier, a number of developing world-based technology companies such as Alibaba, Tencent, Green Dreams, and DataDyne have developed unique BD- and cloud-based apps for the developing world. As discussed in Chapter 8, Novatium developed cloud-based

mobile applications, mainly in its Indian R&D centers. In September 2011, Novatium services had over 40,000 users in India. Ericsson's principal target groups for the applications are emerging markets, where most consumers cannot afford a PC. In developed markets, the company focuses mainly on young consumers.[33]

As mentioned, BD- and cloud-based mobile computing solutions hold a special appeal for developing countries. Such solutions provide the best opportunity to overcome barriers related to ICT infrastructures and level the playing field for MSMEs. A number of philanthropic foundations' support to these technologies have facilitated the diffusion of BD- and cloud-based mobile computing solutions in developing economies.

11.5 Policy Implications

Governments have a critical role to play in order to overcome barriers related to skills shortages, information gaps, poorly functioning markets, and inadequate infrastructures by adopting and implementing relevant policies, laws, and regulations.[34] Such mechanisms are also needed to accelerate the development of the BD and cloud industry and market.

Investor-friendly policies such as tax incentives, subsidized credits, infrastructure investment, market deregulation, and special start-up programs can help attract BD and cloud companies. The Internet & Mobile Association of India (IAMAI) called for new tax incentives for locating data centers in a country: direct corporate tax rates and indirect sales taxes.[35] China's Guizhou province (Chapter 1) also illustrates this point. Favorable policies are elevating Guizhou from being one of the most backward provinces to a prominent BD hub. The province's per capita GDP in 2015 was less than two-thirds of the national average.[36] Guizhou offers various tax breaks and grants to technology firms. BD enterprises that meet certain requirements are exempt from corporate income tax for the first two years and benefit from a 50 percent corporate income tax reduction for the following three years.[37] The province also offers housing allowances to attract BD talent. Companies can register in the Guizhou province, without setting up physical facilities. In 2014, the governments of Guizhou province, Guiyang City, and Gui'an New District agreed to work together to allocate at least 100 million CNY annually during 2014–2016 to develop the BD industry.[38] In 2016, the Guizhou province announced plans to invest a further 100 billion yuan to develop the BD and cloud sectors.[39]

What is viewed as a disadvantage for an economy can actually be an advantage in the BD era. For instance, the Taiwanese manufacturer Foxconn took advantage of Guizhou's cool weather to establish an air-conditioning-free data center inside a cave located on a mountain in the province.[40]

In light of rapid technological change, developing countries need to manage privacy and security matters in BD and the cloud by issuing forward-looking

regulations that manage risks associated with the evolution of new technologies. For instance, an estimate by Gartner suggested that IoT security will account for 20 percent of annual security budgets by 2020 compared to less than 1 percent in 2015.[41] As was highlighted above, many governments in developing countries need to strengthen their legal and regulatory framework in the field of data protection and privacy.

11.6 What Do We Know About BD and the Cloud in the Developing World?

In Chapter 1, we posed three questions: (1) What factors drive the diffusion of BD and the cloud in developing countries? (2) What are the potential economic, social, and political impacts of these technologies in these countries? and (3) What roles can businesses and policy makers play to facilitate the adoption and effective utilization of BD and the cloud?

In this book, we have attempted to answer these questions. Table 11.1 presents the situations in the developing economies regarding the drivers and effects of BD and the cloud, and the implications for businesses and policy makers. The analysis of the book shows that BD and the cloud have the potential to change the competitive landscape of some industries. To illustrate this point, consider the case of e-commerce. Upfront investment and economies of scale hinder small businesses' implementation of advanced e-commerce applications. As discussed earlier, BD and cloud computing have helped Chinese software start-ups access infrastructures and data centers, which would not be possible in traditional models.

Our points about exports of BD- and cloud-related services (Table 11.1) warrant elaboration. In this regard, Bhagwati's theory of kaleidoscopic comparative advantage argues:

> [W]hat we are facing now is a new and steadily encroaching economic universe in which the nature of comparative advantage is becoming thin, volatile, and kaleidoscopic and is creating vulnerabilities for industries, firms and workers.... The margins of competitive advantage have ... become thinner: a small shift in costs somewhere can now be deadly to your competitiveness. We used to call such industries "footloose." ... In the old days, few considered such industries to be the norm. Today, they are the norm.[42]

An obvious example to illustrate how the cloud-led revolution may erode comparative advantage of some industrialized world-based companies is the market for productivity tools, in which Zoho is flexing its muscles.

Chinese companies such as Huawei, Alibaba Group, and ZTE have emerged as challengers to global cloud providers such as IBM, Amazon, and HP, initially

in their domestic market but also internationally.[43] This phenomenon fits well with the theory of kaleidoscopic comparative advantage, which argues that "the nature of comparative advantage is becoming thin, volatile, and kaleidoscopic and is creating vulnerabilities for industries, firms and workers."[44]

In least developed economies, the potential opportunities and benefits have been limited by weak forward and backward linkages. Unsurprisingly, global IT companies have been slow to enter into these economies. When they enter and intensify their activities, however, mechanisms such as labor mobility and stimulation of knowledge and technology transfer and other spillover effects may help local firms develop their capabilities—if they have a certain basic level of absorptive capacity. Some applications of BD and the cloud can help create a virtuous circle, which can act to positively reinforce the further development of the cloud industry. In Vietnam, cloud computing is being used to develop education programs, which would help further strengthen backward linkages.

Nonetheless, the overriding reality is that in developing economies, only a small proportion of organizations and firms are currently positioned to take advantage of advanced technologies such as BD and the cloud. IT-intensive industries (e.g., software development in China) or those dealing with IT-enabled processes (e.g., offshoring sectors in South Africa) are benefiting more from BD and the cloud than most other economic sectors. With improved connectivity and awareness, however, BD and the cloud are likely to gain momentum in the developing world.

BD- and cloud-based business models are still evolving. For local and global cloud providers, success in developing economies hinges on having business models that focus on affordability and consider the unique needs and capabilities of small-scale consumers (including MSMEs). Governments in the developing world can collaborate with domestic and foreign cloud players to support the development of software and other products appropriate for the local needs.

Cloud-related innovations and business models that leverage existing infrastructure and technologies in novel ways undoubtedly have potential benefits. Perhaps the greatest barrier for the adoption and effective utilization of the cloud in the developing world is the low PC penetration and a limited as well as expensive bandwidth. This will favor the mobile-based cloud solutions in low-income countries. First, a cellphone capable of running a browser can already access mobile clouds. Low-cost phone users can thus tap into applications that are currently accessible only through smartphones. Second, consumers in the developing world are using increasingly sophisticated devices.

Not long ago, there were very few applications available for developing world-based users such as China Mobile's BigCloud platform and Salesforce's "offline PDA."[45] Now, cloud-based mobile applications are becoming increasingly pervasive, which are set to transform the way mobile phones are used in the developing world.

BD and the cloud in most developing countries are still at an early stage of development. Rather than viewing these technologies as a self-contained phenomenon, they must be seen against the backdrop of economic and institutional realities. In theory, there are many possible uses of BD and the cloud and several channels and mechanisms through which developing economies may benefit. In practice, however, serious problems stand in the way of implementation and practical gains. BD- and cloud-based innovations and business models are yet far from inclusive of SMEs in the global South, especially in the least developed, small nations.

Currently, BD and cloud usage has been shallow, narrow, and vanishingly small in most developing economies. Small developing economies lack the infrastructure and economies of scale for wide and deep cloud adoption. It would thus be unreasonable to expect that the cloud would help the developing world catch up with the West in one big leap. However, as economic and institutional factors improve, BD and the cloud offer a possible avenue towards bridging the digital divide. The developing world thus should seek to exploit the opportunities afforded by the cloud while minimizing the associated risks to allow access to advanced IT infrastructure, data centers, and applications, and protect sensitive information.

Some potential impacts of the cloud in the developing world include productivity gains, the development of innovative services (e.g., personalized insurance), efficient supply chain management, implementation of B2B e-commerce, and the development of a skilled workforce. We argued that the cloud might erode the comparative advantage of incumbents. While some developing world-based companies such as Alibaba and Zoho have challenged industrialized world-based multinational companies, in the present context, cases like those are extreme.

11.7 Future Research Implications

Before concluding, we suggest several potentially fruitful avenues for future research. First, in terms of geographic focus, we limited our analysis to a few major economies. For instance, some of the most high-profile and interesting BD projects in the primary sector are being undertaken in Vietnam.[46] In the future, conceptual and empirical work scholars need to compare and contrast the cloud and BD development processes in developing economies not considered in this book.

In this book, we reviewed several BD- and cloud-based solutions that have been developed locally as well as in the developed world. A second area of future research might be to compare locally developed BD and cloud solutions with those developed in the industrialized world in terms of a number of parameters such as costs and performance. Such research should also consider how technology transfer within developing economies might compare with North–South transfers.

TABLE 11.1 Key Findings and Implications

	Situation in the Developing Economies and Implications
Drivers of the BD and cloud industry in the developing world	• Development and structure of related industries that produce forward, backward, and horizontal or inter-sectoral linkages are tightly linked to the development and diffusion of BD and cloud computing. • Local firms' technological capabilities generate positive externalities for the development of BD and the cloud industry. • Institutional legitimacy issues such as the government's support and institutional preferences affect the development of the cloud industry.
Potential impacts	• BD and the cloud help improve physical (infrastructures) and economic (lower price) access. • Changing the competitive landscape of some industries: upfront investment and economies of scale hinder small businesses' implementation of advanced e-commerce applications. The cloud has helped Chinese software start-ups access infrastructures and data centers, which would not be possible in traditional models. • Performance indicators related to export activities (e.g., cloud-related entrepreneurship) point to developing world-based technology firms' shift into a higher gear, which may erode the industrialized world's comparative advantages. • Market for productivity tools: currently Western multinationals such as AWS, IBM, and Microsoft dominates this market in the USA as well as in the developing world. Developing world-based companies such as Alibaba and Zoho can emerge as strong challengers, mainly by emphasizing lower price and broader accessibility.
Roles of businesses and policy makers	• Strengthen forward and backward linkages: helps attract global cloud players and maximize the benefits of the cloud computing to the local economy. • Measures to create a virtuous circle: Vietnam, the cloud is being used to develop education programs, which would help further strengthen backward linkage. • Measures to increase awareness among potential users: would help create a strong forward linkage. • Promotion of business models that leverage existing infrastructure (e.g., cellular phones): cellular phones are the primary computing device and means for accessing the Internet for a large proportion of population in developing economies.

The IoT is evolving as a key force that is transforming economic, social, and political institutions in the developing economies. A third area of future research concerns the analysis of the IoT as a key source of BD in these economies. Future research needs to analyze how data from IoT can be used in the developing world to bring positive economic, social, and political outcomes. It also needs to consider in greater detail the implications of IoT for data protection and privacy as well as data security.

11.8 Final Thought

A key favorable condition is the emergence of some economies in developing economies as hotbeds of innovations in BD- and cloud-based solutions. Locally created innovations and solutions such as iCow have particularly promising opportunities to improve the living standards and welfare of the poorest members of society.

The case of China's Guizhou province suggests that it is possible to use BD and the cloud to transform underdeveloped regions. However, economically disadvantaged groups such as smallholder farmers and low-income populations may not be in a position to take actions on their own to benefit from these advanced and modern technologies. The case of Guizhou province and other similar economies also suggests that motivated and forward-looking politicians, governments, and interest groups can take actions and make decisions to bring economic and social transformations even to the most backward and economically weak areas.

Notes

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