CHAPTER 7

Instilling Digital Trust

Blockchain and Cognitive Computing for Government

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INTRODUCTION

Despite broad technological progress, modern transaction systems remain heavily burdened by antiquated practices, creating "friction" that slows international commerce and inhibits service delivery of all kinds. For example, banks still issue letters of credit to importers, a practice that has remained virtually unchanged for 700 years since its origin in medieval Italy. The practice requires the costly and time-consuming entry of a banking intermediary for many transactions.

Likewise, cross-border regulations, customs delays, fraud, corruption, and graft are frictions that add a significant layer of costs, delays, and complexity to global trade and business flows. An IBM test determined, for example, that paperwork alone accounted for 15 percent of the cost of a shipment of produce from Africa to Europe.

The emerging digital technologies called "blockchain" and "cognitive computing" can help reduce or eliminate these frictions.[1]

Friction inhibits not only trade and business flows, but also people. Small farmers, evaluating the costs of shipping produce overseas—from bank fees to paperwork to bribes—may decide it is simply not worth the time and money to try to sell outside of local markets.

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[1]Blockchain is a shared, immutable digital ledger for recording the history of transactions. As each transaction occurs, it is put into a block. Each block is connected to the one before and after it. Transactions are linked together and each block is added to the next in an irreversible chain. Cognitive computing employs key artificial intelligence technologies to augment human capabilities and expertise.

To be sure, successful economic transactions are based on trust. And digital technologies and other innovations can disrupt economic order, thereby undermining trust by disturbing the status quo and inviting unfamiliar or risky conditions.

Nonetheless, many technological advances have significantly expanded trust throughout history. Innovations such as paper money, banking systems, the printing press, and electronic payment systems have all done so. The internet, which initially fueled access to new ways of buying and selling without a host of guarantees and safeguards, quickly introduced consumers to secure e-commerce.

Each of these advances spurred economic activity by creating systems that enhanced trust so that parties could more freely engage with one another. If seemingly disruptive digital technologies engender greater trust, they can stimulate economic improvements while providing distinct advantages to those who adopt them.

Digital disruption replaces large, capital investment with cloud-based technologies that grow as needed to handle increasingly larger workloads.[2] They are "disruptive" in that they often upend traditional business and service delivery models, while offering new value to consumers. The business models of companies like Amazon, Airbnb, and Uber offer powerful examples (Chapter 3). Using more efficient digital interfaces between consumers and the providers of goods and services, they have revolutionized the retail, hospitality, and transportation industries, respectively.

This chapter looks closely at how blockchain and cognitive computing can help government become more transparent, accurate, and efficient in its activities. Indeed, these technologies are already being applied to tax collection, delivery of public benefits, digital citizen identity, land registry management, and public records.

Governments may not think of themselves as employing "business models." They exist to serve their citizens. But here, too, digital disruption can radically alter both the way governments meet this mandate and their speed and effectiveness in doing so. Blockchain and cognitive computing are digital disrupters that will help accomplish this goal while instilling greater trust, security, and enhanced risk management across government operations.

HOW BLOCKCHAIN AND COGNITIVE COMPUTING WORK

As noted, digital technologies can reduce friction and increase trust in transaction systems. Blockchain accomplishes this by putting data into shared,

[2]Cloud computing, often referred to as simply "the cloud," is the delivery of computing resources—everything from applications to data centers—over the internet on an as-needed, pay-for-use basis.

distributed ledgers[3] that allow every participant access to the system of record for a transaction, using a "permissioned" network—one that can distinguish who has permission to see what. Only parties involved in the transaction can see and make alterations to it. A transaction, once executed, cannot be changed. And because it is distributed, no malicious actor can make harmful changes without others knowing about it.

And because they can process and analyze massive quantities of both structured and unstructured data, *cognitive systems*, in turn, can use this blockchain data to gain valuable insights and detect patterns in nearly-real time from multiple data streams.[4]

Digital technologies can also remove barriers to economic participation by lowering costs and simplifying administrative processes. For example, blockchain can eliminate the costs of verifying transaction information, which currently takes place at various points in time throughout the transaction. Since every party has access to the same information at the same time, verification costs may be reduced or eliminated. This lowers the price of auditing transaction information, reducing the barrier for entry for new participants into the marketplace (Catalini and Gans 2016).

To understand blockchain and cognitive computing, it is first useful to view them in the context of information technology's longstanding role in helping governments and financial systems.

The Tabulating Era (1900–70)

The earliest computers involved single-purpose, mechanical systems that counted. These tabulation machines supported the progress of both business and society, helping governments and businesses understand and manage major challenges from population growth to the advance of global capitalism.

For example, in 1937 punch-card systems pioneered by IBM enabled the US government to implement a sweeping new program of social security for nearly 30 million citizens.

The Programmable Era (1950s–present)

Counting, though, was insufficient for the major societal challenges that emerged. Computers that could follow detailed instructions—often using if/then logic—combined with rapidly advancing telecommunications, helped create cross-border payment systems, electronic payments systems, a system of international bank settlements, and transactional websites for internet banking, to name just a few. Advances in this era have also led to billions of connected people with

[3]A distributed ledger is a database that is consensually shared and synchronized across participants in a business network that can span multiple sites, institutions, or geographies.

[4]Computers easily understand and work with structured data, which is organized in columns, tables, databases, and the like. Unstructured data—such as the words in this book or the information contained in a video—has traditionally required humans to understand. Cognitive systems can process both kinds of data.

mobile phones, making knowledge and services dramatically more accessible and cheaper.

The Cognitive Era and Blockchain (2011–present)

Today's advances, particularly in applying artificial intelligence technologies to augment human cognition, are beginning to introduce an easier way to interact with computing systems. This method uses natural language, accesses information in images and audio files, and collaborates with systems that learn from human expertise and continue to increase in knowledge. Today, the volume, complexity, and unpredictability of world data are unprecedented. Cognitive computing's greatest strength is its ability to handle enormous loads of complex data, extract meaning from them, and propose ways to act on newfound insights.

But how data are collected, stored, and maintained can be critical to their effective use, and no more so than in complex transactions involving multiple parties from various jurisdictions. Integrating a rigorous, trustworthy method of ensuring accurate transaction data like blockchain with cognitive computing capabilities will help people and governments solve practical problems, find new opportunities, boost productivity, and foster new discoveries. The combination of blockchain and cognitive systems offer further opportunities to transform business and financial transactions of many kinds.

How Blockchain Works

A blockchain is a distributed ledger that allows records (blocks) to be added and securely maintained in a way that prevents tampering or revision. It emerged as the core technology underpinning the digital currency known as Bitcoin. However, its uses go far beyond payments and have the potential to touch all aspects of the real economy.

Blockchain technology can be used to share a digital ledger of transactions across a business network without being controlled by any single entity, making it simpler to establish cost-efficient trusted relationships. It establishes trust and integrity without relying on third-party intermediaries.

In a private blockchain network, cryptography ensures that participants can view only information in the ledger they are authorized to see. This is an important distinction from public blockchains, such as Bitcoin, that are accessible to anyone. The permissioned feature of private blockchain networks is critical to establishing adequate levels of privacy and data integrity. Once committed to a blockchain, transactions can never be changed since no node can unilaterally alter its copy of the ledger. In effect, participants cannot rewrite history or deny past transactions.

Blockchain's business-rule feature (also known as "smart contracts") enables certain conditions to be imposed automatically on transactions, such as that two or more parties must endorse them, or that another transaction must be completed first. For example, instead of obtaining a letter of credit from a bank, an importer of goods could utilize a smart contract on a blockchain stating that when goods

cross a specific point and customs authorities approve it, money flows back from the receiver's bank to the sender's bank immediately, without a waiting period.

The blockchain ledger can record every sequence of a transaction from beginning to end, whether it involves hundreds of steps in a supply chain or a single online payment. As will be explained, because of the transparency made possible by blockchain, government agencies can gain a better understanding of what is occurring within financial and commercial systems and identify potential problems before they become critical.

In 2015, IBM and 16 other cross-industry leaders formed Hyperledger, a Linux Foundation project that is using an open source approach to advance cross-industry blockchain technologies. Open source methods provide the transparency, interoperability, and support required to bring emerging technologies forward to mainstream commercial adoption. Participants can freely license, use, copy, and adapt related software for specific applications. The source code is openly shared among members so that software design can be voluntarily improved, though in a consistent, controlled manner.

This approach ensures that blockchain development proceeds with uniform standards and applications in mind, an important goal given the potential application of the technology to a wide range of industries. The open source process, combined with liberal licensing terms and strict governance by multiple organizations, will enable the broadest adoption of blockchain by regulated industries (US Congress 2016).

How Cognitive Computing Works

Cognitive computing describes systems that apply artificial intelligence technologies to learn at scale, reason with purpose, and interact with humans naturally. These systems perform functions that resemble what people do when acquiring knowledge, understanding and learning from it, reasoning on it, and then sharing what is known. Cognitive systems offer evidence-based decisions, continuing to refine them based on new information and results, so that humans can make better decisions and choose better actions.

Cognitive computing systems differ in significant ways from the information systems that preceded them. They are probabilistic, as opposed to deterministic, meaning they do not follow a lengthy, but finite, set of directions that end in a single solution to a question or problem. They use statistical reasoning—such as analyzing the likelihood of two word phrases being related, or how often they appear together—to begin to make hypotheses about potential meaning and answers. They generate hypotheses, piece together reasoned arguments, and make recommendations for action with an associated probability or confidence measure.

Unlike conventional computing systems, cognitive systems can also process and derive insight from the 80 percent of the world's data classified as unstructured (Kelly 2015). This is fast becoming an essential function given the exponential growth of such data and the pressing need to exploit value as quickly as possible for business and societal gain.

Generally, cognitive systems are:

- *Adaptive:* They learn as information changes, and as goals and requirements evolve. They help resolve ambiguity and tolerate unpredictability. They can process dynamic data in real time or near real time.
- *Interactive:* They interact more naturally with and adapt to people using them. They may also interact with other processors, devices, and cloud services, as well as with people, and can make use of more traditional programmable systems to complete a task.
- *Iterative:* When faced with incomplete or ambiguous problem statements, they can ask questions or find additional input to further define the problem. They can "remember" previous interactions in a process and return information that is suitable for the specific application at that point in time.
- *Contextual:* They understand, identify, and extract contextual elements such as meaning, syntax, time, location, appropriate domain (relevant business sector) and regulations, the task at hand, and its goal. They draw on multiple sources of information, including both structured and unstructured digital information, as well as sensory inputs such as visual, gestural, auditory, or sensor-provided.

IBM's Watson is perhaps the most widely known example of a cognitive computing system that reflects the above features today. It combined innovations in more than a dozen disciplines of advanced computer science to defeat the top human champions on the quiz game show *Jeopardy!* in 2011 by understanding and answering spoken language questions faster than its opponents.

Since then, Watson has been trained to analyze increasingly complex data sets from specific business domains and to reason, draw insights, and learn from them. Consider, for instance, health care fields such as oncology.

The amount of research and data available to help inform cancer treatments is growing exponentially. Medical professionals cannot possibly keep up with all of it on their own. Watson for Oncology helps care teams identify key information in a patient's medical record, surface relevant articles, and explore treatment options to reduce unwanted variation of care. The system was trained for 15,000 hours by specialists at Memorial Sloan Kettering Cancer Center in New York. It has ingested nearly 15 million pages from relevant journals and textbooks and continues to expand its knowledge.

Watson combines understanding of the longitudinal medical record and its oncology training to quickly recommend options to physicians for each unique patient case. This capacity has been made available to healthcare providers around the world. For example, in trials at the University of North Carolina's Lineberger Comprehensive Cancer Center, in one-third of the cases Watson suggested potential treatment options that the hospital's tumor board had not considered. Manipal Hospitals in Bangalore, India, found that Watson agreed with its tumor board recommendations in 90 percent of cases of breast cancer.

Watson's potential is not limited to health care. It is also being used to assist local and national governments with various core activities such as customer service.

The US Census Bureau has enlisted IBM to support its Census 2020 Program with cognitive technologies to help answer respondent questions. Anyone filling out the 2020 Census will be able to call an 800 number where the Watson system will answer natural language questions. It is expected that increasing self-service with the help of virtual agents will lead to significant cost reductions.

Similarly, Miami-Dade County, Florida, has enlisted IBM to enhance customer self-service for the Water and Sewer Department through Watson and IBM Cognitive Solutions. With the help of a cognitive advisor, customers of the department can engage with Watson on an array of questions about water services and payments. The goals of the new system are to increase first call resolution, provide customer advocacy, billing information, and payment options. The service is expected to reduce cost per contact as well as provide around-the-clock answers and support to customers.

BLOCKCHAIN AND COGNITIVE COMPUTING APPLICATIONS TO PUBLIC FINANCE

Blockchain Potential Benefits

While blockchain's potential benefits touch almost all industries, its potential for government is particularly promising, because it has the capacity to provide far greater levels of transparency, accuracy, and efficiency in government activities. As noted, it is already being applied to a wide range of functions including tax collection, the delivery of public benefits, digital citizen identity, land registry management, and public records, to name just a few.

Blockchain's business rules feature could be adapted to perform a regulatory function, perhaps even at no cost to outside parties involved in government transactions. Government policies and terms could be digitally enshrined in the "smart contracts" that underpin a blockchain, ensuring that those policies are executed faithfully across all transactions conducted on that blockchain.

Blockchain offers governments the possibility of establishing permanent, immutable records of identity, for citizens and businesses, that cannot be lost or stolen. This, in turn, establishes the access to data required for enhanced service delivery and the distribution of public benefits. Nearly 2.5 billion people in the world today lack official identification, including children up to age 14 whose birth has never been registered, as well as many women in poor rural areas of Africa and Asia. This is a major impediment to accessing welfare benefits, education, and broadening financial inclusion (Daha and Gelb 2015).

For example, Estonia, well-known for its early adoption of digital technologies, is the first nation to offer its citizens a digital identity card based on blockchain. Citizens can use it to access public, financial, and medical and emergency services; pay taxes online; e-vote; provide digital signatures; and travel within the European Union without a passport (Shen 2016). Through another program

called e-Residence, Estonia provides a transnational digital identity for non-Estonians and nonresidents of the country. It can be used to establish a location-independent online business registered in Estonia and to utilize digital services like those accessible by Estonian citizens and Estonia-based businesses.

Finally, blockchain, in tandem with cognitive systems, can help governments and industry alike ensure provenance, the chronology of the ownership, and custody or location of an asset or object, as the example below demonstrates.

Well-documented provenance demonstrates that an item is authentic. This has enormous implications for everything from food safety, to the integrity of life-saving drugs, to the health and well-being of consumers. Provenance creates an auditable record of transport of all physical products. It can prevent the sale of counterfeit goods as well as the problem of "double spending" of certifications present in current systems.

A relevant industry example is IBM Research's work with Everledger, a company that tracks and protects diamonds and other valuables. Diamonds depend on certificates of authenticity and origin that are still largely paper-based. As a result, this information is more vulnerable to tampering. It also poses a major challenge to regulators trying to prevent the flow of "conflict diamonds" into the market, which have been tied to funding for armed insurgencies.

Everledger has built a digital business network using IBM Blockchain to underpin its global certification system. The platform holds digital information on 1 million diamonds, including industry certifications and key data points with links to laser inscriptions inside each stone. A cognitive computing system ensures that these diamonds are authentic and compliant with thousands of regulations, including those imposed by the United Nations to prevent the sale of conflict diamonds.

For the first time under this system, cognitive analytics can be performed directly on data within the blockchain, where it resides. This prevents the need for the data to be extracted for analysis, which makes it more susceptible to fraud. The system can cross-check all relevant regulations and records as well as supply chain and Internet of Things data, including time and date stamps and geospatial information, in a fraction of the time it takes humans to do this.[5]

Everledger believes this system can eventually be applied to a whole range of high-value goods—everything from priceless works of art, to rare wines, to automobiles. In a similar way, IBM believes blockchain can benefit certain key government activities as highlighted in Table 7.1.

[5]The Internet of Things refers to the growing range of connected devices that send data across the internet. A "thing" is any object with embedded electronics that can transfer data over a network without any human interaction. Examples are wearable devices, environmental sensors, machinery in factories, devices in homes and buildings, or components in a vehicle.

Table 7.1. Blockchain Benefits to Government

Benefit	Challenge	How Blockchain Can Help
Revenue Collection	• Diverse taxpayer base of companies and individuals • Legacy processes • Complex financial obligations • Auditability	• Smart contracts automate transactions under specific legal agreements • Immutable record of financial obligations and transactions • Increased transparency • Outside auditing and regulatory reviews are made easier
Expenditure Accountability	• Auditability and regulatory oversight • Confidentiality of sensitive personal information • Budget priorities	• Security is enhanced through encryption and cryptology • Consensus required for changes to the ledger improves data integrity • Immutable chain of transactions establish provenance
Anticorruption	• Opaque governance models • Complex financial systems • Corrupt financial practices	• Network architecture can meet predefined governance models • Regulator participation supports automated compliance • Single version of truth for all permissioned parties in the network • Increased visibility between parties in the network • Supports data encryption and the management and enforcement of complex permission settings for participants and third parties

Source: IBM Research.

Applications of Blockchain and Cognitive Computing to Revenue Collection

Government revenue collection also offers a helpful lens through which to view the potential impact of blockchain and cognitive computing.

Revenue collection is currently a separate process from the commercial transactions on which it depends. It happens periodically and is contingent upon the trustworthiness of the parties involved to record transactions correctly. The government collects tax when an invoice is settled with a supplier. This might occur on a quarterly basis, for instance, and require the completion of a tax return. With blockchain, companies would not be required to submit a return as their tax account could be continuously maintained and settlement could be automated.

The existing separation between the commercial transactions and their tax component also encourages both deliberate and accidental under-reporting. Cognitive systems can spot this under-reporting by looking at the patterns of commercial transactions and their relative tax generation.

This integration of cognitive analytics with blockchain technology can considerably reduce the risk of error in the taxation of commercial transactions. Blockchain's security and immutability help ensure that the provenance of the sequence of transactions is established, reducing the possibility of fraud and error. The tax transaction on the blockchain can be automatically generated from the

commercial transaction. Smart contracts can be employed to implement current tax policy, enabling tax authorities to deploy any amendments quickly and effectively. And cognitive systems can continually scour the blockchain data to look for anomalous behavior and other exceptions that might signal noncompliance or fraud.

With tax transactions and key elements of the commercial transaction on blockchain, government can execute compliance activities continuously at no additional cost to commercial entities. The tax owed by each taxpayer could be stored on the blockchain as a digital currency (US dollars) and backed by the central bank. This digital currency could be used to settle tax due and to net tax allowances, for example when processing value-added tax. In this way, taxpayers would no longer need to submit filings, as the net tax account would be maintained continuously on the blockchain.

IMPLEMENTING DIGITAL TECHNOLOGIES: KEY CONSIDERATIONS FOR GOVERNMENT

Costs and Challenges

Any form of technology acquisition requires financial investment that will vary according to each potential adopter's existing infrastructure and needs. It is therefore difficult to generalize about the cost of digital technologies such as cognitive computing and blockchain to government. This must be determined on a case-by-case basis. Cost will also moderate as these technologies mature and scale up with wider use.

Despite these unknowns, certain core assumptions can be made about the relative affordability and overall value of blockchain and cognitive-computing-based solutions.

As noted previously, these solutions can now be delivered through cloud computing. While initial access may require certain upgrades to existing computer hardware and software, cloud-enabled services largely preclude the need for large, capital-intensive technology investments. Based on private sector projects IBM is currently involved in, an investment in the single-digit millions of US dollars is sufficient to get digital technology projects up and running on a relatively large scale. Viewed against total government spending, this is not a prohibitive cost, even in developing countries. For example, the government of Kenya announced that overall government spending would amount to more than $22 billion in fiscal year 2017/18 (Njini and Changole 2017).

It is also true that countries in developing regions may be at a distinct advantage when it comes to digital technology adoption owing to their relative lack of existing technology infrastructure. They do not have to maintain older "legacy" systems common to much of the developed world. They can choose to build out a modern infrastructure, underpinned by blockchain and cognitive computing, rather than retrofit equipment that may be several decades old.

A more urgent challenge, and one that government is uniquely positioned to address, lies in the process changes that are required for digital adoption. Taking the example of blockchain, the technology is expressly designed to facilitate multi-party business interactions. Its adoption requires cooperation and participation from private sector entities, which must agree to a new set of policies on transactions and data sharing built around blockchain. This necessitates changes in policies, which government can facilitate, as opposed to a technical solution, which it cannot.

While the combination of cognitive systems and blockchain is inherently secure, security and technical challenges will likely develop. Drawn by the increasing numbers of users of these new technologies, computer hackers and cyber-criminals will attempt to find and exploit new vulnerabilities. The large volume of trusted information that can be shared on a blockchain could also increase the risk of participants compromising some part of the system.

But the primary challenge to security will remain people that are part of the system, as opposed to the technologies themselves: blockchain cannot prevent data from being corrupted at the source by a human, such as if an official were bribed to submit a phony transaction. Various security innovations are now taking place at the "edge" of the network, near the source of the data, to complement blockchain technology and address this challenge. These include promising work on cryptographic, tamper-proof anchors and tiny computers that can securely link a physical product with its digital representation in a blockchain system and help eliminate fraud in complex, global supply chains.

Despite the potential challenges, blockchain will still make it far harder for malicious actors to commit transactional fraud because of the following three core capabilities:

1. Every transaction is digitally signed making it non-repudiable.
2. Every transaction is vetted by two or more parties via a consensus mechanism (one cannot unilaterally enter information into the blockchain).
3. Data on the blockchain are immutable because multiple copies of it are managed by independent parties. It is also grouped into blocks and transactions are chained cryptographically, making it virtually impossible for anyone to tamper with information once entered.

Finally, there is the longer-term challenge of how to manage the indefinite growth of data on a blockchain, given that it is an append-only log of all transactions. While not insurmountable, this is an important technical consideration and work is under way to understand how it can best be resolved.

Legal Framework

IBM's experience has been that a significant number of the advantages of digital technology adoption can be realized without the need to change existing legal and regulatory frameworks. Many years helping thousands of public and private sector clients adopt digital technologies make clear that most advantages can be

realized within current law. This has proven true in financial services, supply chain and logistics, health care, and other industries. Given the proximity of these industries to government services and oversight, it will likely hold true for government adoption as well.

Yet it is also true that by definition, innovation precedes regulation. As digital technologies like blockchain and cognitive computing spur a reimagination of many business processes, need will likely emerge for new legal and regulatory modifications to maximize their potential and guide their use. For example, certain digital documents (such as a digital bill of lading in shipping) are not considered legally admissible in some jurisdictions. In such cases, blockchain-based systems for managing secure document approval workflows may not be feasible until such laws are modified.

Privacy

Blockchain's central promise is to deliver trusted data and business processes to users by enabling permissioned and selective visibility into data. Its security features can be configured to comply with existing privacy laws (such as the European Union's General Data Protection Regulations and others), and its privacy controls are a function of policy decisions, not technology limitations. Viewed in this light, a blockchain can be made to mirror the strength of the laws themselves. The technology can also be configured to generate supporting documents such as automated audit compliance reports, increasing trust in the audit process.

A private blockchain network's permissioned feature prevents anonymous entities from taking part in a transaction, which minimizes the potential for criminal use. This is in sharp contrast to well-publicized uses of Bitcoin's public blockchain ledger for alleged criminal purposes.

Sequencing

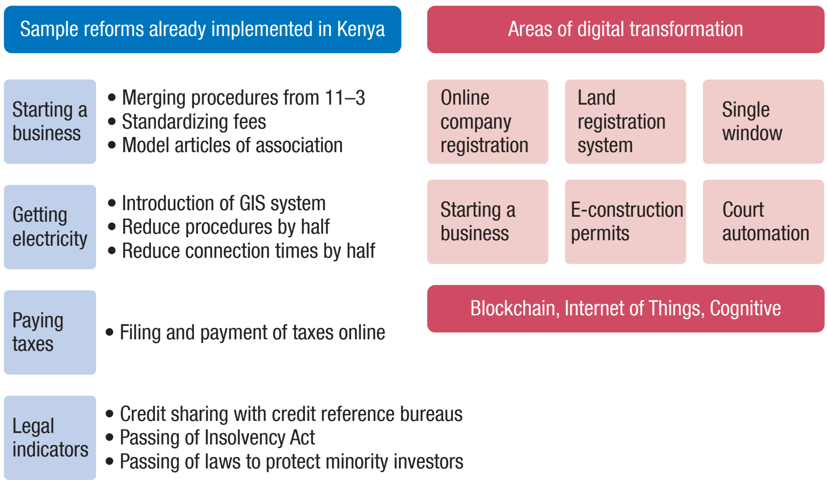
Successful government technology projects must be undertaken with an optimal order of steps or "sequences" in mind. These sequencing steps should include legal assessments, determination of impact, and capacity development.

Certain lessons can be drawn from IBM's work in Kenya to improve that country's business environment to attract more foreign direct investment and strengthen domestic firms. Above all, this effort requires enhancing the efficiency of government services and the underlying regulatory framework. In IBM's experience, these are essential precursors for successful technology adoption.

The key sequencing steps in IBM's Ease of Doing Business project in Kenya included the following:

- Data collection from various agencies to determine the root cause of the observed inefficiencies
- Data analysis to develop recommendations for reforms (process, legal, and technology)

Figure 7.1. Reforms in Kenya's Ease of Doing Business Project



Source: IBM Research.

- Development of an action plan to aid implementation
- Implementation of technology to transform governance
- Implementation monitoring
- Communication to stakeholders of implemented reforms

Figure 7.1 illustrates reforms and technology recommendations that have already been implemented in Kenya based on this methodology.

As one indication of the success of this approach, Kenya has dramatically improved its World Bank Ease of Doing Business ranking, used by countries throughout the developing world to gauge reform success. Kenya's ranking rose a total of 44 places in the past two years and in both years, it was rated the third most reformed country in the world. IBM Research is now expanding the focus of this project by developing cognitive technologies to help government officials make more informed decisions about policymaking, revenue, and expenditure.

OTHER GOVERNMENT AND INDUSTRY APPLICATIONS

Governments and industries worldwide are actively experimenting with blockchain and cognitive computing. Applications include welfare payments distribution, government customer service and call centers, digital currencies, electronic records, land titles, citizen identity, fraud prevention, global supply chain security, and many more. The following discusses specific projects.

Currency and Payments

African nations have advanced national payment systems to rival and exceed those in many western countries. Examples include M-Pesa in Kenya (Chapter 10), a mobile phone-based money transfer, financing, and microfinancing service, as well as the beginnings of the world's first blockchain-based digital currencies in Tunisia and Senegal.

In Tunisia, more than 3 million citizens have no banking relationship (DCE 2015). The Tunisian government aims to use digital currency to improve this through blockchain technology. Using a smartphone application offered by the Tunisian National Post Office, which provides bank accounts and has a 45 percent share of the country's banking market, clients can have nationwide access to instant, secure, and affordable merchant payments and remittances. They can use the digital currency, known as eDinar, to make instant mobile money transfers, pay for goods and services in person and online, pay bills, and manage government identification documents (Parker 2015).

Senegal has also announced plans to use a blockchain-based digital currency in 2017 called eCFA. The currency would be legal tender with the same status as the existing currency, the *Communaute Financiere Africaine* (CFA) franc. Unlike other forms of digital currency, supply of eCFA would be controlled by the Senegalese central bank in the same way as physical currency (Douglas 2017).

Welfare Disbursement

In the United Kingdom, the government's Department of Work and Pensions, the country's largest public service department, is engaged in a pilot project to employ blockchain's distributed ledger technology to improve the payment of welfare benefits. It is aimed in part at reducing the £3.1 billion that is overpaid in benefits in the United Kingdom each year (National Audit Office 2016). Claimants use a mobile phone application to receive and spend their benefit payments. With their consent, their transactions are recorded on a distributed ledger to support their financial management.

Bond Issuance

The retailer Overstock is using blockchain technology for the global issuance, settlement, and trading of corporate bonds. The private bonds Overstock has issued this way offer same-day settlement, instead of the two or three days it typically takes. In 2016, Overstock became the first publicly traded company to issue stock over the internet, distributing more than 126,000 company shares through technology based on blockchain (Metz 2016).

Global Financing

IBM Global Financing is the world's largest technology financier. Yearly, it facilitates credit among 4,000-plus suppliers and partners worldwide and

handles nearly 3 million invoices and 25,000 disputes. The unit created a blockchain platform to reduce dispute times from more than 40 days to under 10, freeing up about $100 million in capital that is otherwise tied up at any time (Krishna 2016). With blockchain, participants in the transaction share a single platform with permissioned and secure access. They receive a full view of the process and can easily track transactions from purchase order to product delivery. They are also able to see every step in a transaction and identify the exact moment of a delay or error. This enables parties to the transaction to resolve problems more easily without filing a dispute.

Global Supply Chain

Maersk, the world's largest shipping company, has collaborated with IBM to build the first industrywide cross-border supply chain solution on blockchain. The solution will help manage and track the paper trail of tens of millions of shipping containers across the world by digitalizing the supply chain process from start to finish. By enhancing transparency and the secure sharing of information, the platform can reduce the amount of paperwork currently required to ship goods, thereby lowering transaction costs. Blockchain's immutable and transparent audit trail will also begin to address the approximately $600 billion lost every year to maritime fraud, when goods are illegally removed from ships during transactions (WIRED 2017).

Dubai Customs is working with IBM to explore the use of blockchain for the import and re-export process of goods in and out of Dubai. The blockchain solution transmits shipment data through a cloud computing delivery system, so that key stakeholders will be able to receive instantaneous information about the condition of goods and shipment status. Taking the example of the journey of a shipment of fruit, parties in the transaction will receive timely updates as the fruit is exported from India to Dubai by sea, then manufactured into juice in Dubai, and exported as juice from Dubai to Spain by air. The solution aims to replace paper-based contracts with smart contracts. It uses data from sensor devices to update or validate smart contracts (including the condition of fruit). And it integrates all key trade process stakeholders from the ordering stage, in which the importer obtains a letter of credit from its bank, through the intermediary stages of freight and shipping, ending with customs and payment.

A SIMULATION OF HOW BLOCKCHAIN ADOPTION COULD BENEFIT GOVERNMENTS

The emerging nature of digital technologies and their early stages of adoption in most instances makes existing data about impact on national economies scarce. Therefore, we examine the potential effect of blockchain use on

three developing economies with the help of the Oxford Economic Global Model.[6]

As an exercise, the scenario focuses on three countries: South Africa, Kenya, and Nigeria. Because South Africa offers a more robust set of baseline statistics, it is used here as the primary example in presenting the methodology and results.

To see the benefit of blockchain, we imagine the government of South Africa decides to take a different policy path to accelerate digitalization of the economy.[7] Perhaps even more importantly, the government commits to establishing nationally mandated standards that allow businesses to participate seamlessly in a new and simplified transactional world by leveraging blockchain technology.

Blockchain, as noted, is designed to remove the friction of global commerce, that is, the many additional transactions that complicate the flow of goods and services and drive up overall cost. These include everything from excessive processing times to numerous fees charged by intermediaries, multiple inspections of goods at border checkpoints, administrative paperwork, corruption, and other inhibitors. IBM estimates that more than $300 billion in the underlying costs of global commerce can be optimized with digital technologies like cognitive computing and blockchain (Krishna 2016).

BASELINE ECONOMIC ASSUMPTIONS FOR TRANSPORTATION AND HANDLING EXPENSES

Before presenting the results of the macroeconomic model, it is important to understand the key underlying assumption of how revenue is allocated in the typical transaction. Generally, revenue is parsed across several cost categories: labor costs, operating costs, transportation and handling expenses (TE), and profits.

[6]Oxford Economics has developed a fully integrated global macroeconomic model. The model is Keynesian demand driven over the short term, combined with monetarist concepts driving the longer term. The combination allows for shocks to demand that can generate recessions, with economies responding to monetary and fiscal policies. However, output over the long term is determined by supply-side factors, such as investment, demographics, labor participation, and productivity. This quarterly model covers 80 countries and the remaining smaller nations are aggregated into six regional blocs and the euro area. All countries covered are linked to each other through trade flows, world prices, interest rates, exchange rates and other factors. Nations vary in coverage, with the United States and the United Kingdom leading the model, with over 850 variables, and Iraq the smallest coverage, with just over 170 concepts covered. See Oxford Economics for more information: http://www.oxfordeconomics.com/about-us.

[7]The focus here is on measuring benefits. Of course, there are costs as well, including acquisition and deployment costs and transition and transformation costs. The former is a small part of the total costs, while the latter reflects the need to change organizational processes and procedures, retrain workers and managers, and engage with third parties in new and different ways. As is well known, organizations often resist such change, making transition and transformation costs high. These costs are captured by spreading the implementation of the new technology over four years, forgoing the full benefit during implementation.

Labor costs include wages, salaries, benefits, training, recruiting, hiring, and all other costs related to labor. Operating costs include costs of materials, plant and facility operations, taxes, and all other costs of producing a good. TE includes all expenses required to ship and move a good through its supply chain to the buyer. Profits include earnings, depreciation, interest, and all other returns to capital. Ratios vary, but the generally accepted equation is as follows:

Revenue =	Profits +	Labor Cost +	Operating Cost +	Transportation Expense
	10%	70%	15%	5%

Our scenario focuses on using blockchain adoption to reduce the cost of TE. We assume that 5 percent of revenue for transportation and handling expense is reasonable.

Worldwide, the transport and storage industry accounts for 4.1 percent of total industrial output, not including any of the output involved in the retail and wholesale sectors.[8] In the trade and transportation sectors, the TE ratio rises to 15.9 percent (NACE 2008).

Transport costs typically consume 10 percent of total revenue of a product (Rodrigue and Notteboom 2017). Transportation costs within the US mining sector typically run 4–5 percent of total revenue (Eurostat 2008).

We assume that 20 percent of TE, or 1 percent of total revenue, falls as a result of the cost reduction in our scenario. This is based on three examples:

1. Within the airline industry, passenger services, ticketing, station and ground, and administrative costs are a combined 23 percent of the total (Leinbach 2005).
2. In container shipping, more than 40 percent of the total logistics costs are indirectly due to delays that include additional inventory demurrage costs and bribes paid at a wide variety of police checkpoints and weighing stations. Overland shipping in Africa is characterized by significant lost time in regulatory delays. For example, transporting goods from Mombasa to Nairobi takes an average of 30 hours, with 10 hours spent at security checkpoints and six hours at regulatory weigh stations (Rodrigue and Notteboom 2017). This added time requires an additional 11 hours of driver rest and meals. In contrast, a similar distance traveled across the North America Free Trade Agreement trade zone takes only six hours. Unreliable transportation shipping times not only add costs, they can also make a perishable shipment worthless. In addition, each stop along the way opens the supply chain to graft. At best, consumers bear the added cost; at worst, such friction restricts trade among potential partners.
3. In carrying out a test case using a shipment of avocados from Mombasa to Rotterdam, IBM calculated the cost of moving the shipping container itself to

[8]The transport and storage industry is defined in Eurostat (2008, 76). The 4.1 percent estimate can be found at Oxford Economics aggregates, using data from national statistical offices http://www.oxfordeconomics.com/.

be approximately $2,000. The cost of the paperwork associated with it comes to $300, 15 percent of the total (Allison 2017). By removing much of the processing time for paperwork and other inefficiencies through digitalization with blockchain, IBM showed vast cost and time savings.

Under this assumption, our scenario lowers the rate of increase of the consumer price index (CPI) by 20 percent. Consider the following:

CPI(*t*) = CPI(*t* – 1) * (1 + Rate of Inflation(*t*)) * (1 – (TE percent * Change in TE percent))

If the CPI(*t* – 1) is 100 with a rate of inflation of 5 percent, then a 20 percent reduction in TE costs (assuming TE costs 5 percent of revenue) results in a CPI(*t*) of 104. The apparent rate of inflation will be reduced to 4 percent. An array of factors determines the rate of inflation, including the actions of the nation's central bank, while the reduction in TE costs is a result of the introduction of the newly available technology.

SIMULATION OF COST REDUCTION ASSUMPTIONS IN THREE AFRICAN ECONOMIES

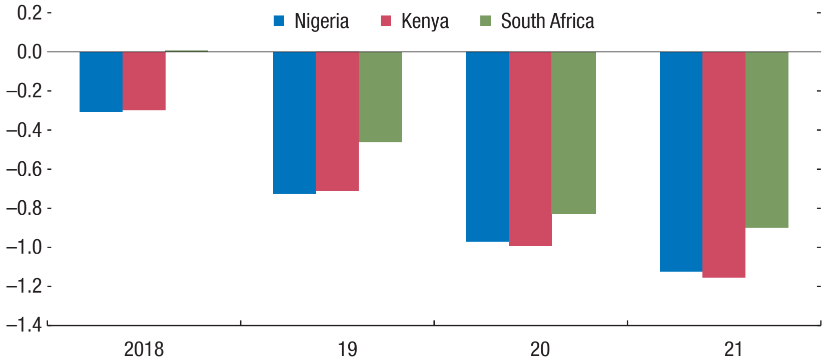
Employing the Oxford Economic Model, the exercise simulates the impact of the introduction of the new technology as a one-time supply shock. Because of the transition and transformation costs, four years are required to realize the full benefit of the new technology. While the cost reduction is permanent, it is a one-time event. Future benefits would require the introduction of additional technology improvements or other positive supply shocks.

To achieve consistent results, the same methodology is applied in the model to blockchain adoption in Kenya, Nigeria, and South Africa. However, only annual data are available for the model for Kenya and Nigeria, whereas the South African model is quarterly. This has implications for the scenario. For South Africa, the changeover to prices occurs over the course of a year, while in the annual models the result occurs at once. In the scenarios, prices change dramatically in the annual models and considerably more slowly in the quarterly model.

In broad terms, the lower rate of inflation flows through to all the appropriate price metrics including CPI, producer price index, import and export prices, wage costs, and the GDP deflator.[9] These changes have immediate impacts on all nominal data series. Figure 7.2 presents a change from the baseline and not absolute growth rates. For example, in 2018 the Kenyan GDP deflator, economywide

[9]The 1 percent cost improvement contributes to a reverse wage-price spiral lowering wage-price expectations and producing a 2.1 percent price level decline over four years in South Africa, a 2.7 percent price level decline over four years in Nigeria, and a 3.0 percent price level decline over four years in Kenya.

Figure 7.2. Change in GDP Deflator
(Percentage point reduction from baseline)



Source: Authors' calculations with Oxford Economics model.

inflation, rises 5.4 percent in the baseline and 5.1 percent in the IBM scenario. The resulting 0.3 percentage point reduced inflation is shown in the chart.

Generally, lower inflation is very positive in the three simulated cases. Real GDP responds in this scenario. For example, Kenya's real GDP rises 6.4 percent in 2018 in the baseline and 6.9 percent in the scenario, or 0.5 percentage point of additional GDP growth.

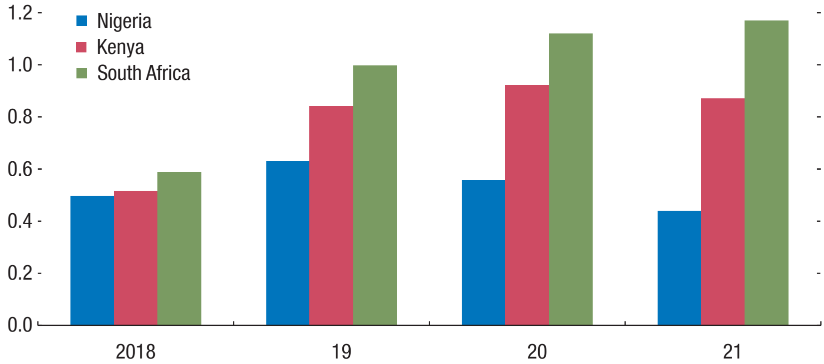
In both cases shown in Figure 7.3, the Nigerian and Kenyan economies encounter supply constraints as they are unable to sustain expansion at such rapid rates. The technology cannot remove all growth constraints faced by these nations. For these economies, strong growth in 2018 and 2019 leads to slower growth relative to the baseline in 2020 and 2021. However, on balance real GDP is higher in all four years than it would be in the absence of the technology. It is unlikely that all the benefits will vanish.

Compared to the baseline, the Kenyan economy realizes 0.9 percent additional real GDP. By 2021, the real GDP in Kenya is nearly a percentage point higher than it would be in the absence of the technology. The Nigerian economy adds 0.4 percent of real GDP.

The improving economy slows government expenditures and raises revenues, reducing the government deficit. Figure 7.4 shows the improvement as a percentage of GDP. For example, the current baseline projection for South Africa in 2021 is a rand (R) 194 billion (US$14.9 billion) deficit. Under the simulation with digital adoption, the deficit is R158 billion, or an improvement of R35.6 billion. As a result, the South African deficit as a percent of GDP is improved from 3.1 percent to 2.6 percent, an improvement of 0.5 percentage point.

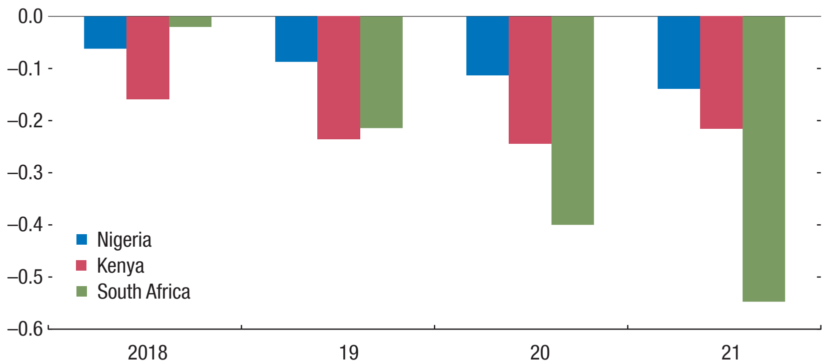
In the scenario, South Africa stands out for its comparatively large fiscal balance improvement. There are two reasons for this result.

Figure 7.3. Real GDP
(Percent improvement from baseline)



Source: Authors' calculations with Oxford Economics model.

Figure 7.4. Reduction in the Government Deficit
(Percentage point reduction, as percent of GDP from baseline)



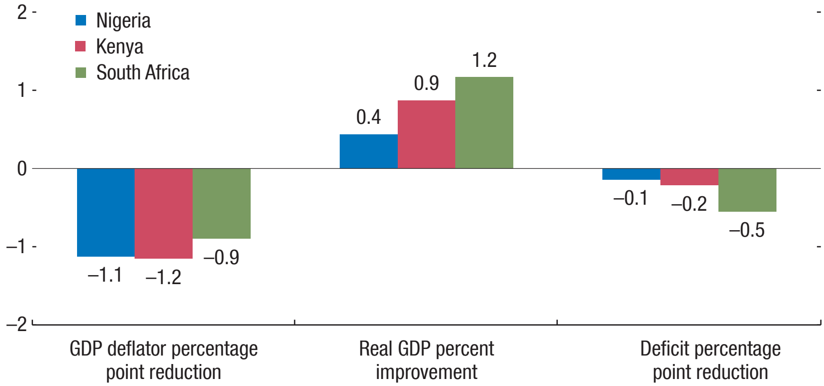
Source: Authors' calculations with Oxford Economics model.

First, as shown in Figure 7.5, South African real GDP relative to the baseline in 2021 is 1.2 percent larger compared to 0.4 percent for Kenya, or nearly three times the improvement. Therefore, the impact to the deficit will be much larger.

Second, and not as obvious, the econometric model for South Africa is more complex. South African government spending data include more detail, notably about interest payments and interest rates. The data for Kenya and Nigeria do not have a comparable level of detail.

For South Africa, as inflation and interest payments fall, the model simulates the fiscal balance response. With lower nominal interest rates, the government can allocate more spending to pay down principal, which in turn generates lower

Figure 7.5. Simulation Highlights 2021 Impact



Source: Authors' calculations with Oxford Economics model.

future interest payments. The resulting virtuous cycle quickly produces long-standing and permanent gains. The assumption that there are no sudden tax cuts or additional spending is critical to the improved fiscal outcome. These options could both be very tempting to implement given the improved fiscal position.

Cost savings slowly filter through the economies of Kenya, Nigeria, and South Africa over four years. On average, removing the transaction friction involved in transportation, handling, and inventory reduces inflation by 1 percentage point from the baseline forecast. In the scenario, real GDP expands by 0.85 percentage point. The improvement in the real economy feeds into higher government revenue and lower government expenditure, resulting in an 0.3 percentage point reduction of the deficit as a percent of GDP.

While this exercise using formal modeling cannot guarantee real-world results, it does demonstrate the potential power of blockchain adoption using tools that are accessible to government planners.

RECOMMENDATIONS FOR GOVERNMENT

As discussed throughout this chapter, blockchain and cognitive computing can be transformational for many facets of governmental operations. But to realize their full potential, governments must ensure that certain preconditions are in place.

Standardize Data Models Nationally and Globally

For cognitive systems to learn continuously and provide decision support capabilities, they must have access to large-scale, high-quality data sets. It is therefore essential for governments to have standardized data models, starting at a national level and broadening internationally to the extent possible. Standardization

improves the quality of data to be acted upon by minimizing "noise" (extraneous or misleading data) and facilitating information sharing across different sectors and countries. The adoption of standardized models will enable rapid, high-volume, high-quality data collection, which is a core requirement for cognitive systems and blockchain.

Standardize Process Models

While tax laws vary from nation to nation, the basic processes that apply to public finance are very similar. These include work flow, document management, authentication and certification, case management, and others that are ripe for improvement. These processes could be made even more efficient with the help of standardized process models. Such models could streamline data flow and drastically reduce required investment in resources (hardware, software, and human). Moreover, they would enhance the ability of cognitive systems to extract key insights from government data.

Invest in Human Skill Development

Human labor is a finite resource, as are the budgets that support them. The key to success in adopting disruptive technologies is to update human skills rapidly to harness the potential of the new technology. Higher-value jobs that require human judgment, domain expertise, goal setting, relationship building, and creativity are the perfect partners for cognitive systems that support them. They will drive the success of collaborations between people and systems in areas such as counter-fraud, compliance, and citizen-customer engagements, among others. One way to do this is by improving the quality and quantity of the data that fuels digital technologies like cognitive computing and blockchain. Highly skilled humans are the key to overcoming barriers to data sharing and collection. As human skills are updated, lower-value repetitive tasks can be standardized and automated, allowing more efficient use of revenue resources.

Engage in Digital Experimentation

For governments to transform core functions with digital technologies, it will be important for them to develop a flexible, iterative approach to experimentation. Revenue services and treasuries, for example, will need to develop "sandboxes" where they can experiment with specific applications of emerging technologies, such as cognitive and blockchain, in isolation from existing systems. This will enable them to assess the value of these applications and improve them continuously based on the analysis of data outcomes before moving to full-scale implementation. It will also give governments the opportunity to develop the right policy framework to accompany any new applications being introduced.

Such an approach could provide a valuable opportunity to update the skills of government workers by placing them within an innovation ecosystem that includes start-ups and private companies.

CONCLUSION

This chapter argues that the growth and widespread adoption of disruptive digital technologies like blockchain and cognitive computing are both inevitable and essential because of the powerful benefits they provide to users. They are poised to transform the business processes of many industries that are now actively experimenting with them. They can also be used to transform key government public finance activities.

Indeed, it has been said that blockchain is poised to do for transactions what the internet did for information. Blockchain's distributed ledger technology has the potential to build trust into every transaction and remove barriers to doing business globally.

For governments, adoption of these technologies is also a responsibility. Countries everywhere are struggling to deliver sustainable economic growth, adequate social benefits, and efficient public services to their citizens. They face extraordinary budgetary pressures arising from events and vulnerabilities that are extremely difficult to factor into planning using conventional computer systems. These factors include economic downturns, revenue declines and leaks, potential shocks to financial systems, and demographic shifts that impact welfare disbursement. To manage these and other challenges more effectively, governments can utilize blockchain and cognitive computing to help them navigate complexity in operational environments and improve their engagement with constituents.

One way to do this is by using these technologies to understand and interpret fast-growing and complex bodies of data. Ginni Rometty, the IBM chief executive, has referred to data as the "next natural resource," due to its abundance and value to society (Rometty 2013).

But much of these data are messy, unstructured, and unreadable to conventional computing systems. Cognitive computing systems, in contrast, are designed to ingest and interpret massive quantities of unstructured and structured data and discern valuable patterns and insights from both. In a global economy, where time is of the essence in managing crises and value increasingly comes from information, this is a vital capacity for governments and industries to possess.

In a similar way, trusted information, as provided by blockchain, can serve as the foundation for an expansion of the global marketplace by allowing new entrants to participate who otherwise might be shut out—everyone from small farmers to small business owners. Blockchain can help achieve this in large part through the costless verification of transaction data. Blockchain removes the prospect that a trading partner will have to engage in an expensive and time-consuming audit should a transaction with a smaller, lesser-known party go wrong. With a single version of transaction data on a ledger, all the required information to settle a dispute may be evident and visible to everyone who has permission to see it on the blockchain. The audit trail is laid out in one place and there is no need to involve costly intermediaries.

Governments can also draw assurance from the relatively low cost of adopting blockchain and cognitive computing solutions by implementing their delivery

through the internet and cloud computing. Moreover, the benefits of these technologies have been shown so far to require few changes to legal and regulatory frameworks. However, their effectiveness can be greatly improved by changes in key data gathering and sharing processes that governments must have the means and the will to implement.

Like all technology, cognitive computing and blockchain will change the way people work. The vast majority of new technologies have broadly benefited human populations over time. They have dramatically improved industrial output, leading to far fewer grueling jobs. But such disruptive improvements are always associated with periods of training and adjustment.

Inevitably, people adapt best by finding higher value in new skills. Technologies that are easiest to integrate will be those that improve human productivity and are easy to interact with. But they cannot replace human judgment. Blockchain and cognitive computing were designed from the beginning to work in concert with human expertise. Governments can help lead the way in developing that expertise for a new technology era and in realizing the full potential of these emerging technologies for all of society.

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