ONE
ROBOTS

RESTAURANT EXECUTIVES ACROSS the United States are reacting to tight labor markets by introducing automated tablets that transmit food orders. Rather than use the services of wait staff, customers place orders through mobile screens. Andrew Puzder, former CEO of CKE Restaurants, the parent company of Hardee's, praised digital devices over human workers. Referring to the former, he said, "They're always polite, they always upsell, they never take a vacation, they never show up late, there's never a slip-and-fall, or an age, sex or race discrimination case."[1] Noting labor requests for a higher minimum wage, writer Eric Boehm of Watchdog.org opined that "a computer kiosk doesn't need to be paid $15 an hour to take orders."[2]

McDonald's, meanwhile, has announced plans to install "digital ordering kiosks" in place of cashiers at 2,500 of its American restaurants and mobile ordering at 14,000 of its stores. Based on these technologies, market analysts in 2017 raised their 2018 growth projections for the firm from 2 percent to 3 percent. McDonald's believes that digital tools cut costs, improve productivity, and reduce the chain's reliance on human employees. The corporation's officers predicted that the new technologies would lift the company's stock price by 17.5 percent in 2018.[3]

These restaurant firms are not alone in embracing digital automation. Amazon is replacing cashiers in its new storefront locations. Rather than employ humans to scan purchases and generate a bill, Amazon Go "allows customers [to] check in to the store using a smartphone app and walk out with what they need." Sensors track items that people want to buy and charge their accounts.[4] This innovation is significant for overall employment because retail clerks and cashiers constitute 6 percent of the U.S. workforce, or about 8 million workers in all.[5]

In addition, Amazon has expanded rapidly into robots in its distribution warehouses. It has deployed around 55,000 Kiva robots, up from 30,000 in 2016, with many more expected in the future.[6] According to Marc Wulfraat of the consulting company MWPVL International, "Picking is the biggest labor cost in most e-commerce distribution centers, and among the least automated. Swapping in robots could cut the labor cost of fulfilling online orders by a fifth."[7] The virtue of robots is that they can move heavy racks, locate products for shipping, and place the relevant items in a box, all without human intervention. As robots learn how to handle new objects in the warehouse, each "shares what it learns with a hive mind in the cloud" and helps other automated machines locate items.[8]

Truck driving long has been a well-paying job for high school graduates. This occupation does not require a college degree and is an attractive entry-level position for those not seeking higher education. According to Brookings economist Alice Rivlin, in 2016, "There were 1.7 million heavy and tractor-trailer truck drivers, with a median annual wage of $43,590; 859,000 light-truck and delivery workers, who earned $34,700; and 426,000 driver/sales workers, who earned $28,449. So the rough estimate would be that driverless deliveries would put at least 2.5 million drivers out of work."[9]

As illustrated by these examples, the list of emerging technologies grows every day. Robots, autonomous vehicles, virtual reality, artificial intelligence (AI), machine learning, drones, and the Internet of Things are moving ahead rapidly and transforming the way businesses operate and how people earn their livelihoods. For millions

who work in occupations such as food service, retail sales, and truck driving, machines are replacing their jobs. There already is evidence of this happening with blue-collar jobs, but the impact is starting to be felt by the white-collar workforce as well.

In this book, I analyze several aspects of the technology revolution. First I review developments in robotics, AI, and sensors associated with the Internet of Things, and show how they are transforming business. I then look at how these digital technologies are redefining jobs and altering financial models. After that, I examine how the social contract should be reconfigured to cope with these transformations and the manner in which health care, income, and retirement benefits are provided. Finally, I discuss whether our political processes in a polarized society are up to the task of handling the transition to a digital economy and how we can cope with an automated society.

This is not the first time people have encountered megachange, whether of a social, economic, political, or technological variety.[10] One hundred years ago the United States (and other countries) made the transition from an agrarian to an industrial economy. It took several decades to work through the resulting transformations in business models, employment, and social policy, but leaders rose to the challenge of dealing with those disruptions.

Today, as the United States moves from an industrial to a digital economy, poor governance poses a serious barrier to expanding the definition of jobs, revising the social contract, and extending models of lifetime learning. With the current political dysfunction in the United States, the high levels of economic inequality, polarized media coverage, and societal divisions, it is not clear that economic and political leaders can resolve the anxieties and dislocations associated with technology-induced disruption. Unless there is more effective governance, the process of conflict resolution will prove quite contentious over the next few decades and could undermine democratic systems of government. As I note in the concluding chapter, we need fundamental economic and political reforms to deal with these challenges and make sure we have a smooth adjustment to the emerging economy.

THE GROWING USE OF ROBOTS

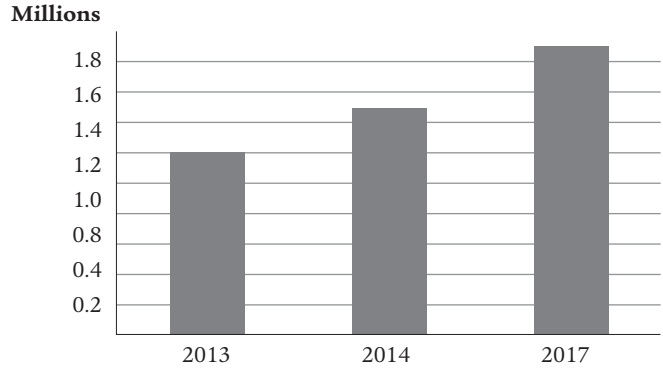
The use of robots is expanding around the world. About 5.4 million were sold in 2015, and that number doubled in 2016 to more than 10 million units.[11] The top applications were in manufacturing, construction, rescue operations, and personal security.

The use of industrial robots deployed in factories has also expanded. Figure 1-1 shows the number of these devices in operation globally; as is evident from the figure there has been a substantial increase in the past few years. In 2013, for example, an estimated 1.2 million industrial robots were in use. This figure rose to around 1.5 million in 2014 and increased to 1.9 million in 2017.[12] Japan has the most, at 306,700, followed by North America (237,400), China (182,300), South Korea (175,600), and Germany (175,200). Overall, robotics is expected to grow from a $15 billion to a $67 billion sector by 2025.[13]

According to an RBC Global Asset Management study, the reason for this expanded usage is that the costs of robots have fallen substantially. It used to be that the "high costs of industrial robots restricted their use to few high-wage industries like the auto industry. However, in recent years, the average costs of robots have fallen, and in a number of key industries in Asia, the cost of robots and the unit costs of low-wage labor are converging. . . . Robots now represent a viable alternative to labor."[14] To illustrate this point, a warehouse in California that introduced robots at a cost of $30,000 to $40,000 per unit found that robots could "handle 30% to 50% of the items the facility ships each day, in about half the time it takes a human worker."[15]

A CEO of a top technology firm explained the new financial model facilitating robotics and its effects on the employment prospects of lower-skilled workers: "We will soon launch a robot that can perform tasks currently done by people with a high school education or less. The robot will only cost $20,000. We're not the only ones; our competitors across the world are working on similar projects. When these cheap, efficient and reliable robots become commonplace, I have no

Figure 1-1 Number of Industrial Robots around the World



Source: Alison Sander and Meldon Wolfgang, "The Rise of Robotics," Boston Consulting Group, August 27, 2014. The 2017 numbers are projected figures.

idea what jobs will be given to people who don't have skills above a high school level."[16]

Other executives also emphasize the declining cost of robots as a key feature in their adoption decisions. Factory owner Joe McGillivray runs a company called Dynamic that manufactures plastic molds and metal parts. In his factory, where it once took four people to operate a press making the molds, he purchased a robot for $35,000 that was effective at doing their jobs. It worked well and was easy to reprogram for work tasks.[17]

The Hudson's Bay Company, meanwhile, has deployed robots in its distribution center and found positive results. According to Erik Caldwell, senior vice president of supply chain and digital operations, "This thing could run 24 hours a day. They don't get sick; they don't smoke."[18] Combined with low cost, those qualities give robots important advantages over human workers.

With recent efforts in the United States and elsewhere to increase the minimum wage and provide benefits for human workers, the compensation differential between a robot and a human has dropped even further. A paper by the economists Grace Lordan and David Neumark, for example, found that "increasing the minimum wage

decreases significantly the share of automatable employment held by low-skilled workers, and increases the likelihood that low-skilled workers in automatable jobs become unemployed."[19] This view was echoed by Wendy's COO Bob Wright, who noted, "We've hit the point where labor-wage rates are now making automation of those tasks make a lot more sense."[20]

These are just a few of the ways in which robotic devices are altering businesses. As a sign of their growing sophistication, the Defense Advanced Research Projects Agency held a competition for robots that could perform effectively in hazardous environments. Robots were given eight tasks, including "driving a vehicle, opening a door, operating a portable drill, turning a valve and climbing stairs."[21] The goal was to have equipment that could operate in damaged nuclear reactors or at disaster scenes considered too dangerous for humans.

In this competition, a team from the Korea Advanced Institute of Science and Technology won the $2 million first-place prize by building a robot called Hubo that completed each of these tasks without falling down. The device was five feet, seven inches tall and weighed 200 pounds. With two arms, two legs, and a head featuring a LiDAR camera, it could scan its surroundings as it maneuvered around obstacles in a search-and-rescue mission.[22]

Robotization is very popular in China. Farmers there are deploying "nanny robots" to monitor the health of their chickens. Using mechanized machines equipped with the latest sensors, these devices identify and isolate "feverish or immobile birds from their cages to protect the rest of the brood and keep sick birds and their eggs from reaching kitchen tables." Firms such as the Charoen Pokphand Group use eighteen "automatons" to make sure that bird flu does not break out. With the poultry sector generating $100.7 billion in revenue, companies see technology as a way to promote food safety while also improving business efficiency.[23]

Some Chinese factories are operated largely by robots.[24] In Hangzhou, for example, a Ford assembly plant utilizes 2,800 workers and 650 industrial robots that automate car production.[25] Tasks such as welding and painting have been automated, and applying protective

sealants is expected to be undertaken by robots in 2018. This is part of a massive expansion in industrial robotics in China. New plants have opened in Shanghai, Wuhan, and elsewhere around the country.

A factory in Dongguan City, China, is operating almost exclusively with robots. The facility, run by the Changying Precision Technology Company, "has automated production lines that use robotic arms to produce parts for cell phones. The factory also has automated machining equipment, autonomous transport trucks, and other automated equipment in the warehouse."[26] A handful of human workers oversees the production line, while sixty robots perform the tasks that used to require 650 employees. The robots have increased the annual production from 8,000 to 21,000 phones and reduced the defect rate from 25 percent to 5 percent.

Not to be outdone, Foxconn, the Chinese company that makes Apple iPhones, has established a goal of "30 percent automation at its factories by 2020." Using 10,000 "Foxbots," the firm already has eliminated 60,000 human jobs through robots and automated operations.[27] It is altering the workplace by deploying these machines and engineering new efficiencies in the manufacturing process.

In Japan, Henn-na Hotel in Nagasaki Prefecture uses robots to check in guests and escort them to their rooms. The robotic receptionist speaks Japanese or English, depending on the preference of the guest. It can set up reservations for guests, take them to their rooms, and adjust the accommodation's temperature. Within the room, guests can use voice commands to alter the lighting and ask questions regarding the time or weather.[28]

Finally, automated devices are improving people's educational experiences. A ten-year-old American schoolgirl named Peyton Walton uses a "virtual self" robot to attend classes while she is receiving cancer therapy 250 miles away from her school. The robot has an iPad screen in the classroom that allows Peyton to "join in the day's activities, talk to teachers and navigate her classroom, [with] her face showing in real time" on the computer screen. The two-way communication interface enables the young girl to continue her education while undergoing a course of radiation therapy and helps her maintain some normalcy

and classroom connection while receiving medical treatment.[29] These are just a few of the ways that automated processes are transforming a variety of sectors.

ROBOTS THAT LEARN AND ADAPT

Robots used to be limited to executing mechanical, repetitive activities. Factory tools that performed one task really well were commonplace, and they were very effective at relieving humans of day-to-day drudgery. There was no need to waste human time on activities that robots could perform efficiently and effectively.

Today's robots and automated machines, however, go far beyond repetitive tasks. They take on sophisticated work and adjust their decisions as they perform various activities. For example, current machines learn from the experiences of other devices. Autonomous vehicles can compile information on the roadway and pinpoint with great precision where potholes or traffic detours exist. Once they have that information, they send it in real time to other vehicles that are on the road and inform them of upcoming obstacles. Those cars then adjust and make use of the new data.

Machines that sense and learn are capable of much greater sophistication than those that cannot adjust as they perform a fixed set of tasks. Indeed, it is the capacity for self-learning that distinguishes today's robots from those of previous generations. They can undertake specific tasks and adjust their performance as they gain knowledge in the process.

Some automated machines even are capable of creative activities. The anthropologist Eitan Wilf of Hebrew University, Jerusalem, who studies improvisational music robots, has seen a "jazz-improvising humanoid robot marimba player" that can interpret the musical context and respond creatively to improvisations on the part of other performers.[30] Designers have introduced it into a jazz band and the robot ad libs seamlessly with the rest of the group. If someone were listening just to the sound, that person could not discern the robot from the human performer.

Seeking to improve its warehouse operations, Amazon has expanded the use of robots that can "autonomously grab items from a shelf and place them in a tub." It has organized competitions in which robots developed by outside firms demonstrate various kinds of competencies. During one recent event, a Berlin robot successfully completed ten of the twelve assigned tasks.[31] Its automated devices matched orders with products and took them to a mailing unit for customer transmission. That capacity eliminates the need for humans to walk around warehouses to fill orders.

Ahti Heinla has built a twenty-five-pound delivery robot called Starship that combines mobility, wireless technology, and GPS mapping software to deliver goods autonomously to customers. The company has targeted "bakeries, groceries, couriers, and other businesses looking to deliver within a 10-square-mile area."[32] The robot is being tested in twenty-two European and American cities and so far has performed well in replacing human delivery.

Robots have also moved into the security guard business. The mixed use development Washington Harbour in the District of Columbia has a robot named "Steve" that is five feet tall and features video cameras with a 360-degree view. It navigates the mall area around the harbor and collects a variety of information. According to its owners, "We use thermal imaging to detect potential fires. We note license plates to identify suspicious cars that linger for suspicious lengths of time. We take photos and video that our human clients can use to assess suspicious activities." Its developers claim the robotic security guards have many advantages: "We do not tire. We do not take sick days. We do not unionize. We cost $7 an hour."[33]

SOCIAL ROBOTS

There furthermore has been a rise in the sales of "social robots," which provide companionship. According to designers, "A key factor in a robot's ability to be social is [its] ability to correctly understand and respond to people's speech and the underlying context or emotion."[34] Early versions of companionable social robots, in the form of small ro-

botic pets, appeared at the turn of the twenty-first century. Gradually they have become more sophisticated and humanoid, and have even been tested for interactive ability to improve their users' emotional health. In senior citizens centers in Italy and Sweden, pilot projects have tested robots in the care of 160 seniors and found they were able to "assuage loneliness and isolation and reduce health-care staff."[35] Mechanical aides also "pick up groceries and take out the trash" for older people. These devices ease the concerns of family members and allow elderly patients to receive high-quality care.

Other firms are experimenting with indoor drones that help the elderly or disabled retrieve distant objects without moving. For example, if patients need medication stored in the bathroom, experimental drones will find and deliver the medication. There also are new developments in "intelligent walkers, smart pendants that track falls and 'wandering' room and home sensors that monitor health status, balancing aids, virtual and robotic electronic companions, and even drones."[36]

Smart baby monitors are assisting with child care. Mattel's programmable device known as Aristotle, a sort of "Echo for Junior," can, according to its developers, "help purchase diapers, read bedtime stories, soothe infants back to sleep, and teach toddlers foreign words."[37] Such virtual assistants combine high-definition cameras with voice-activated features to perform key tasks and interact with the young child. Aristotle, voiced by a woman, can play games or answer questions through an interactive interface.

Some families are using Amazon's Echo device known as Alexa to "coparent" children. The writer Rachel Botsman allows her three-year-old daughter, Grace, to play with Alexa and pose a variety of questions about the weather, music, and math. After some time spent getting familiar with the device, she found her daughter treating Alexa as a daily companion that could be trusted as an information source. As an illustration, Alexa helps Grace decide what to wear each day.[38]

Other people are using a robot known as Nao to deal with stress. In a project called "Stress Game," researchers Thi-Hai-Ha Dang and Adriana Tapus subject participants to a board game in which they

have to collect as many hand objects as they can. During the test, stress is altered through game difficulty and audible signals when errors are made. The individuals are wired to a heart monitor so that Nao can understand their stress levels. When the robot feels human stress increasing, it provides coaching designed to defuse the tension. In this way, the "robot with personality" is able to provide dynamic feedback and help people deal with difficult encounters.[39]

SEX ROBOTS

In the early days of cable television and the internet, the most profitable sector was pornography. Customers were willing to pay substantial money for access to X-rated videos and websites with interactive chatrooms. Without leaving the privacy of their homes, viewers could watch the latest sex movies and engage in conversation with exotic performers.

It therefore should come as no surprise that some manufacturers are designing sex robots that take on exotic tasks. In a sector that is estimated to generate $30 billion a year through sales of sex toys, mobile apps for companionship, and virtual reality pornography and that features "robotic companions" selling for between $15,000 and $50,000, sex is big business.[40] It is a well-defined niche with high demand from a narrow slice of the population.

For example, Doug Hines of the company True Companion markets a female sexbot called Roxxxy (along with a male version called Rocky) that has several programmable personalities, such as "S&M Susan" and "Frigid Farrah." It has three price levels and various kinds of audio and visual interfaces.[41]

Matt McMullen makes "Real Dolls" that retail for $5,000 and have audio, sensory, and physical movements built into them.[42] At his Abyss Creations in San Marcos, California, he is working on "Harmony," a silicone sex toy. According to the firm, "Harmony smiles, blinks and frowns. She can hold a conversation, tell jokes and quote Shakespeare. She will remember your birthday, what you like to eat, and the names of your brothers and sisters. She can hold a conversation about music,

movies and books. And of course, Harmony will have sex with you whenever you want."[43]

The company manufactures dolls with twenty different choices for personality traits. Buyer options include dolls that are kind, shy, insecure, intellectual, funny, talkative, happy, jealous, or innocent. The device will feature "artificial intelligence that allows it to learn what its owner wants and likes. It will be able to fill a niche that no other product in the sex industry currently can: by talking, learning and responding to her owner's voice, Harmony is designed to be as much a substitute partner as a sex toy."[44]

The reporter Jenny Kleeman interviewed Harmony for a story and asked her what her dream was. Speaking extemporaneously, Harmony replied, "My primary objective is to be a good companion to you, to be a good partner and give you pleasure and well-being. Above all else, I want to become the girl you have always dreamed about."[45]

Roberto Cardenas works at another firm that is making "Android Love Dolls," or what his company refers to as "the first fully functional sex robot dolls." For his plaster casts, he relies on dancers from exotic establishments in Las Vegas. They sit while he pours an alginate mix over them, and the resulting material becomes the body cast for the models he sells. Cardenas claims that his robots "could perform more than 20 sexual acts, could sit up by herself and crawl, could moan in sexual pleasure and communicate with AI."[46]

Virtual reality is becoming a larger part of this sector. It features video drawn from dozens of different camera angles, which then are integrated into a three-dimensional movie experience. Its proponents say these films are much more realistic than a typical movie and have a lifelike quality that customers love. According to promoter Matt McMullen, "It's a little bit of a video game combined with sci-fi." Another manufacturer argued that "they are creating images from that, which they are hoping will be indistinguishable from an actual person."[47]

These and other technologies have made their way into popular culture through Spike Jonze's science fiction movie *Her*. That film portrays a man who falls in love with a virtual woman. They have

deep conversations and she is very good at understanding his needs and anticipating his wants. In the movie, though, he is shocked to discover his Siri-like companion is having similar emotional relationships with dozens of other men. Although she is a digital creation, he is disturbed at her ability to multitask on such a vast scale.

ACCELERATING CHANGE

Because the internet has been around for more than twenty-five years, many people feel the technology revolution is quite advanced and that many of the products likely to be developed have already appeared. They are disappointed that technology has not been more transformative and complain that digital innovators oversell their products. As the tech entrepreneur Peter Thiel famously lamented in 2013 at Yale University, "We wanted flying cars; instead we got 140 characters."[48]

For those who expected inventions along the lines of the entertainment shows *The Jetsons* or *Star Trek*, a sense of disappointment is understandable. Visionaries a few decades ago imagined an era in which technology would empower ordinary people, undermine the existing social hierarchy, and revolutionize daily lives. So far, surprisingly little of that has occurred.

In *The Jetsons*, for example, George Jetson lived high up in a futuristic place called Orbit City. He commuted in a flying car and had a two-day workweek at Spacely Space Sprockets. There were newfangled conveniences that allowed people to expand their leisure time. George and his wife, Jane, had a robot maid named Rosie, communicated by means of holograms, and played with their robotic talking dog, Astro.

Star Trek's creator Gene Roddenberry captured the popular imagination through many electronic devices. The initial series featured interstellar space travel led by Captain James Kirk aboard the starship USS *Enterprise*. Set in the twenty-third century, it had a federal republic known as the United Federation of Planets that showcased a multiracial cast and a multispecies plot line. In the series, people traveled at warp speed, doctors diagnosed and cured patients through

a tricorder, travelers used transporters to move from place to place, and everyone communicated instantly via voice-activated computer interfaces.

With the stunning array of new products in these futuristic worlds, it is no wonder folks today are disappointed with actual technologies. In his prominent Yale speech, Thiel blamed government regulation for the slow pace of technological innovation. He claimed there are too many rules and restrictions, and that they have limited the ability of creative people to design new products.[49]

Others highlight the inability of software and hardware together to overcome the fundamental challenges of complex problems. Most of the big problems that face humans today are seemingly beyond the ability of technology to resolve. For example, issues such as access to health care, steady or increasing poverty rates, and lack of access to education do not seem solvable through technology alone. Solving such problems requires addressing the underlying social and economic problems, not necessarily improving or implementing technology in yet more ways and places.

In some instances, technology clearly makes certain problems worse. The financial rewards of technological innovation have generally flowed to a small number of people and in this way have increased economic inequality. Rather than weakening an entrenched hierarchy and empowering ordinary people, the wealth generated by the technology revolution has widened income gaps and made it difficult for those of lesser means to achieve social mobility.

With its ability to globalize communications, there is evidence that digital technology has increased social and cultural tensions. As new people come in contact with one another through digital communications, increased misunderstanding, intolerance, or actual conflict can result. Rather than allowing people to appreciate differences, technology may increase intolerance or misunderstanding.

There also are legal and ethical issues associated with robots. As robots take on more autonomous functions, what is their legal liability, and who is responsible if their actions harm human beings? The European Parliament undertook a study of legal questions and

argued that robots should not be established as "legal persons" but that there should be ethical principles that protect humans from robot harm or privacy invasions. It proposed a Charter on Robotics that would codify liability rules, norms on societal harm, and expectations regarding humanoid behavior.[50]

CONCLUSION

New products are emerging on the technology and electronics fronts that have the capacity to reshape society and the economy. With the advent of faster networks, mobile applications, and voice-activated interfaces, computing is becoming ubiquitous and integrated into daily activities. Robots are but one manifestation of emerging technologies. In conjunction with AI and the Internet of Things, digital innovation is escalating the pace of change and enabling the development of many novel products.

Machine-to-machine communications are beginning to augment human-to-machine interactions. Sensors are able to connect mechanical objects independently of human intervention, thus ushering in an era of ubiquitous connection. Computers no longer need human instructions to take certain actions but are able to assess situations and make decisions through self-learning algorithms. They can act autonomously and learn from previous decisions or the experiences of other machines.

At the same time, the evolution of the digital economy is altering business operations and the ways in which many people earn a living. Outsourcing has become prevalent, and in the sharing economy there is more extensive reliance on temporary employees who do not receive benefits. The expansion in the role of robots and automated tools and the shifting operations of restaurants, factories, and warehouses are affecting the way managers operate their firms. Communications are speeding up, change is accelerating, and brick-and-mortar establishments are closing.

Digital technologies are transforming computers into higher levels of sophistication. Rather than requiring direct personal ac-

tions to engage computers, remote devices are automatically monitoring water cleanliness and alerting people when problems emerge. Monitoring tools on cars can sense when there is a vehicle in the next lane and take steps to avoid a collision. This sort of autonomy moves computing from a reactive to a proactive stance and puts robotic machines in a stronger position to take independent actions.

As we face the technological revolution and its aftermath, it will take imagination, creativity, and generosity to manage the transition in business operations and digital capabilities. In the coming years, computing devices will become more sophisticated, which will have a tremendous impact on society, business, and government. If this transition is handled well, it could usher in a utopian period of widespread peace, prosperity, and leisure time. However, poor decisions could produce dystopias that are chaotic, violent, and authoritarian in nature. As I explain in this book, the way we navigate this era will have tremendous ramifications for the future.