THE INDUSTRIES OF THE FUTURE

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ALEC ROSS



London \cdot New York \cdot Sydney \cdot Toronto \cdot New Delhi

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Adapt or perish, now as ever, is nature's inexorable imperative. —H. G. Wells, *A Short History of the World* (1922)

THE WRONG SIDE OF GLOBALIZATION

It's 3:00 a.m., and I'm mopping up whisky-smelling puke after a country music concert in Charleston, West Virginia.

It's the summer of 1991, just after my freshman year of college. While most of my friends from Northwestern University are off doing fancy internships at law firms, congressional offices, and investment banks in New York or Washington, I am one of six guys on the afterconcert janitorial crew at the Charleston Civic Center, which seats 13,000 people.

Working the midnight shift is worse than jet lag. You have to decide if you want your work to be the beginning of your day or the end of your day. I would wake up at 10:00 p.m., eat "breakfast," work from midnight to 8:00 a.m., and then go to bed around 3:00 p.m.

The other five guys on the crew were a tough bunch. They were

good guys but beaten down. One carried a pint bottle of vodka in his back pocket, which was done by "lunch" at 3:00 a.m. A scraggly redhead from the hollows, the valleys that run between West Virginia's hills, was sort of near my age. The others were in their 40s and 50s, at what should have been the peak of their wage-earning potential.

The way country music concerts work in West Virginia is people drink way too much. Our job was to clean up the result. The six of us canvassed the arena with enormous jugs of fluorescent-blue chemicals, which, when poured on the concrete floor, would just sizzle.

The last wave of innovation and globalization produced winners and losers. One group of winners were the investors, entrepreneurs, and high-skilled laborers that congregated around fast-growing markets and new inventions. Another class of winners were the more than 1 billion people who moved from poverty into the middle class in developing countries because their relatively low-cost labor was an advantage once their countries opened up and became part of a global economy. The losers were people who lived in high-cost labor markets like the United States and Europe whose skills could not keep up with the pace of technological change and globalizing markets. The guys I mopped with on the midnight shift were the losers in large part because the job they could have gotten in a coal mine years before had been replaced by a machine, and whatever job they could have gotten in a factory from the 1940s to the 1980s had moved to Mexico or India. For these men, being a midnight janitor was just not the summer job it was to me; it was one of the only options left.

Growing up, I thought that life in West Virginia was representative of life everywhere. You were doing your best to manage a slow descent. But the phenomenon I was witnessing in West Virginia really made sense to me only as I traveled the world and saw other regions rising as West Virginia was falling.

Twenty years after pushing a mop on the midnight shift, I've now seen the world and been exposed to the highest levels of leadership in the biggest technology companies and governments around the world.

I've served as Secretary of State Hillary Clinton's senior advisor for innovation, a position she created for me just as she became known as Madame Secretary. Before going to work for Clinton, I served as the convener for technology and media policy on the Obama campaign that beat her in the 2008 presidential primary and had spent eight years helping run a successful, technology-based social venture that I cofounded. My job at the State Department was to modernize the practice of diplomacy and bring new tools and approaches to addressing foreign policy challenges. Clinton recruited me to bring a little innovation mojo to the tradition-bound State Department. We had a lot of success, and at the time that she and I left in 2013, we were ranked as having the most innovation-friendly culture of any cabinetlevel department in the federal government. We developed successful programs to address nasty challenges in places as varied as the Congo, Haiti, and the cartel-controlled border towns in northern Mexico. In the background of all this was the role I played building a bridge between America's innovators and America's diplomatic agenda.

In this time, I spent much of my life on the road. I saw a lot of the world before and after my time in government, but the 1,435 days I spent working for Hillary Clinton gave me a particularly intense, close-up view of the forces shaping the world. I traveled to dozens and dozens of countries, logging more than half a million miles, the equivalent of a round trip to the moon with a side trip to Australia.

I saw next-generation robotics in South Korea, banking tools being developed in parts of Africa where there were no banks, laser technology used to increase agricultural yields in New Zealand, and university students in Ukraine turning sign language into the spoken word.

I have had the chance to see many of the technologies that await us in the coming years, but I still often think back to that stint as a midnight janitor and the men I met there. The time I spent gaining a global perspective on the forces shaping our world helped me understand exactly why life had grown so rough in my home in the hills and why life was getting so much better for most of the rest of the world. The world in which I grew up, the old industrial economy, was radically transformed by the last wave of innovation. The story is by now well worn: technology, automation, globalization.

While I was in college in the early 1990s, the process of globalization accelerated further, bringing to an end many of the political and economic systems that defined yesterday's economies. The Soviet Union and its satellite states failed. India began a series of economic reforms to liberalize its economy, eventually bringing more than a billion people onto the global economic playing field. China reversed its economic model, creating a new form of hybrid capitalism and pulling more than half a billion people out of poverty.

The European Union was created. The North American Free Trade Agreement (NAFTA) came into effect, integrating the United States, Canada, and Mexico into what is now the world's largest free trade zone. Apartheid ended and Nelson Mandela was elected president of South Africa.

While I was in college, the world was also newly coming online. The World Wide Web was launched to the public, along with the web browser, the search engine, and e-commerce. Amazon was incorporated while I was driving to a training site for my first job out of college.

At the time, these political and technological shifts did not seem as important to me as they do now, but the changes that took place while I was growing up in West Virginia and that accelerated with the rise of the Internet have made the lives we lived even just 20 years ago seem like distant history.

Those people in my hometown with worse job security than their parents are still living a better life when you measure it up against what their money can buy today that it could not decades ago, including more and better communications and entertainment, healthier food, and safer cars and medical advances that keep them alive longer. Yet they've been through a raft of changes, both positive and negative. And all this change will pale in comparison to what is going to come in the next wave of innovation as it hits all 196 countries on the planet.

The coming era of globalization will unleash a wave of technological, economic, and sociological change as consequential as the changes that shook my hometown in the 20th century and the changes brought on by the Internet and digitization as I was leaving college 20 years ago.

In business areas as far afield as life sciences, finance, warfare, and agriculture, if you can imagine an advance, somebody is already working on how to develop and commercialize it.

The places where innovation gets commercialized are expanding too. In the United States, breakthroughs are coming not only from Silicon Valley, from the Route 128 corridor around Boston, or from North Carolina's research triangle. They are beginning to come out of Utah, Minnesota, and the Washington, D.C., suburbs in Virginia and Maryland. The breakthroughs will not be exclusively American, either.

After years of growth rooted in low-cost labor, there are promising signs of innovation coming from the 3 billion people who live in Indonesia, Brazil, India, and China. Latin American countries with a face to the Pacific, including Chile, Peru, Colombia, and Mexico, appear to have figured out how to position themselves in the global economy. The highest-skilled labor markets in Europe are producing start-ups that make Silicon Valley green with envy, and in tiny Estonia, "the little country that could," the entire economy seems to be an e-economy.

Innovation is likewise transforming Africa, where even in the refugee camps of the Congo, technologies as simple as the cell phone are connecting people to information and each other as never before. Africa's entrepreneurs are now changing the face of the continent, fueling development and creating a new class of globally competitive businesses.

Everywhere, newly empowered citizens and networks of citizens are challenging the established order in ways never before imaginable from building new business models to challenging old autocracies. The near future will see robot suits that allow paraplegics to walk, designer drugs that melt away certain forms of cancer, and computer code being used as both an international currency and a weapon to destroy physical infrastructure halfway around the world.

This book examines these breakthroughs, but it is not simply a hosanna to the benefits of innovation. Advances and wealth creation will not accrue evenly. Many people will gain. Some people will gain hugely. But many will also be displaced. Unlike the previous wave of digital-led globalization and innovation, which drew enormous numbers of people out of poverty in low-cost labor markets, the next wave will challenge middle classes across the globe, threatening to return many to poverty. The previous wave saw entire countries and societies lifted up economically. The next wave will take frontier economies and bring them into the economic mainstream while challenging the middle classes in the most developed economies.

Across large swaths of the globe, people feel newly under siege by rising inequality and unwelcome disruption. A pervasive sense that it is becoming harder to find your place in the world or get ahead is rattling many societies.

Innovation brings both promise and peril. The same forces that are unleashing unparalleled advances in wealth and welfare may also allow a hacker to steal your identity or hack your home. A computer that can speed up analysis of legal documents can also shrink the number of lawyers in the workforce. Social networks can open doors to form new connections or create new forms of social anxiety. The digitization of payments can facilitate commerce or allow for new forms of fraud.

When I was a college student at the dawn of the Internet revolution, I did not have the slightest inkling of the future that lay ahead. I wish I had been able to read a book back then that took a good stab at what was next. Certainly no one is omniscient, but I have been fortunate enough to gain a glimpse of what lies around the next corner.

This book is about the next economy. It is written for everyone

who wants to know how the next wave of innovation and globalization will affect our countries, our societies, and ourselves.

GROWING UP IN THE OLD ECONOMY

To understand where globalization is going in the future, you have to understand where it's coming from. I grew up in Charleston, West Virginia, a city whose history reflects America's centuries-long rise as an economic powerhouse from the grime-covered mines that helped fuel its growth. West Virginia was built on coal, much the same way that Pittsburgh was built on steel and Detroit was built on cars. Indeed, it was West Virginia's connections through coal to the industrial North that led it to secede from Virginia and the more agricultural South when the American Civil War broke out.

West Virginia's position mirrored that of other mining centers connected to the Industrial Revolution's first manufacturing bases. In the United Kingdom, Midlands cities like Manchester and Leeds became the industrial base. London provided the finance. Coal came from Wales. In Germany, the Ruhr region near the Rhine River valley became a manufacturing center. Coal came from eastern Germany and Poland.

Today coastal China, particularly the areas around Shenzhen and Shanghai, has become the world's factory. Its coal comes from western China and Australia. Similarly, mining regions in India's northeastern peninsular belt, Turkey's Anatolia region, and Brazil's Santa Catarina region supply the industrial bases of their emerging economies and other economies around the world. In each region, mining offers a stepping-stone toward greater economic ties and opportunities—at least for a time.

Building on its coal boom, West Virginia developed complementary industries that cemented its position as an industrial supply center and eventually presaged its decline. In the early 20th century, Charleston underwent its second boom: chemicals. The Union Carbide Corporation established the world's first petrochemical plant in West Virginia in 1920.

With America's entry into World War II, massive amounts of synthetic rubber were needed to meet wartime demands. Union Carbide, which became the largest employer in West Virginia and one of the top ten chemical companies in the world, launched a period of growth that continued well after the war. Between 1946 and 1982, its revenues increased from about \$415 million to more than \$10 billion. During that time, it employed as many as 80,000 people globally, roughly 12,000 of them in West Virginia. And as the company continued to grow, so did Charleston. By 1960, its population had grown to 86,000 from 68,000 before the war.

When I was in school, a big percentage of my classmates were children of chemical company engineers. Their families were often the most worldly, arriving from top universities around the country and the globe. And for over a century, the old-economy industrial fields of West Virginia—coal, chemicals, and plastics—were stable, reliable career choices.

My family came to West Virginia when my grandfather, Ray DePaulo, moved from the coal camps of Colorado during the Great Depression. His high school had closed down due to lack of funds, so they just handed out diplomas to everyone, including my then 13-year-old grandfather. Luckily for him, that was still a time when you could make a living with just a high school diploma.

Once in West Virginia, my grandfather became what we'd now glowingly call an entrepreneur. He went door-to-door selling telephones at a time when people were getting phones in their homes for the first time. He ran a garage, a golf course, a restaurant, a bakery, a parking lot, and a house-cleaning business, much of it out of a stall used by car salesmen.

My grandfather understood one of the curious conundrums of globalization: exposure creates not only opportunity but competition, and it can make us question and eventually lose our standing in the

world. West Virginia, like so many other industrial centers in America, was just realizing its high point during my grandfather's lifetime. But its shortcomings were about to be exposed by new competition from new markets and new machines.

I remember, as a kid, about halfway into the drive between Charleston and my father's law office was a town named Nitro. As soon as we passed Nitro, my brother, sister, and I would all start squirming and squealing in our seats, repulsed by the stench from the chemical factories that surrounded us.

My mother, in the driver's seat, would just breathe it in and matterof-factly say, "That's the smell of money." She identified this horrid smell with jobs—and potential clients for my dad.

In the old economy, this was the smell of money not just in Nitro but in places like Gary, Indiana; Newark, New Jersey; and Baton Rouge, Louisiana. Today that same smell now shrouds industrial sites in China, India, and Mexico even as it still lingers in some of the old industrial centers of America.

The Kanawha River Valley, which runs through Charleston, was known as "Chemical Valley." For almost a century, Chemical Valley hosted the highest concentration of chemical manufacturers in the United States: Union Carbide, DuPont, Monsanto, the Food and Machinery Corporation (FMC), and many, many others.

At night, the valley looked from above like something out of a futuristic film with its towering steel structures of the chemical plants lit up with little lights. The smoke released into the night sky added an orange glow, the whole scene eerily reflected by the river—a river that seemed not to have a single fish or other living animal in it. I never questioned why as I was growing up.

The town of Nitro, 14 miles downriver from Charleston, is named for nitrocellulose, or gunpowder, bringing a literal meaning to the term *boom town*. Nitro was built up during America's mobilization for World War I, when the United States faced a critical shortage in gunpowder production. The US government poured more than \$70 million into building the plant, known as Explosive Plant C, as well as the public structures for the surrounding town. The war ended in November 1918, just after the first shipment of explosives went out.

That was not the last time Nitro participated in a war mobilization. In the 1960s, the former Monsanto chemical plant in Nitro manufactured the herbicide Agent Orange, used by the US military to defoliate jungles during the Vietnam War. Dropping this chemical in the Vietnamese jungle harmed the health of more than 1 million Vietnamese and 100,000 American combat veterans, and it produced birth defects in more than 100,000 children.

It was an ugly trade, but for a while, for the local region, my mother was right: the smell of Nitro meant money. The money did not keep coming, however. Ultimately the very industries that built Charleston and West Virginia also led to their decline.

In the case of the mining industry, mechanization wiped out the need for coal mining by hand. To be a coal miner went from carrying a pick and shovel to operating a machine that could do the job of hundreds of humans. For the chemical industry, globalization meant that businesses could locate their plants in places with fewer environmental regulations and less expensive labor. The chemical companies moved their operations to India and Mexico.

Leaving home became the practical option for many Charlestonians. From 1960 to 1990, Charleston lost 40 percent of its population. By 1988, West Virginia's unemployment rate was close to double the national average. There were fewer children of engineers in my classes as their parents were transferred out of the state or out of the country.

Charleston and West Virginia were representative of cities and states all over the world grappling with postindustrial decline and globalization. Handcuffed to their existing resources and manufacturing industries, these areas flourished through years of stable economic growth. But once the boom ended, they were hit hard with rapid capital and population flight. Their manufacturing facilities, once drivers of wealth, today are dormant steel structures on the city skyline. The steel mills of Pittsburgh shuttered. Detroit's population declined from 1.8 million to 700,000 as its car industry faced new competition from Tokyo and Seoul.

American cities were not the only ones to suffer. Manchester, the world's first industrialized city, lost 50,000 jobs in the 1970s. The coalfields in southern Wales went under, with the last one closing in 2008. The port of Marseilles was ravaged by new competition and saw its population decrease by 150,000 people.

By the time I was in college, the only chemicals that provided secure jobs in West Virginia were the ones that sizzled as they hit the floor of the Charleston Civic Center.

THE RIGHT SIDE OF GLOBALIZATION

As West Virginia faced a decades-long economic descent, those same forces of globalization and labor migration were having positive impacts elsewhere. In India and China, together 40 percent of the world's population, the changes have been eye-popping.

In the 30 years from 1982 to 2012, India's poverty rate dropped from 60 percent of the population to 22 percent. Life expectancy surged from 49 years to 66. When I was growing up, India was the country of Mother Teresa and famine. Today it is a country increasingly defined by technology, global services, and a fast-growing middle class.

The changes in China have been even more dramatic, with its poverty rate plummeting over that same period from 84 percent to 13 percent, pulling roughly 600 million Chinese out of poverty. With an economy 25 times larger than it was 30 years ago, China has become the second largest economy in the world after the United States.

What was bad for industrial America and Europe was very good for India, China, and much of the rest of the world. As globalization and innovation challenged the lifestyles of many of those living in industrial cities and states in the West, it bolstered the economic growth of up-and-coming nations. Beyond developing nations, individuals and states all over the world that took advantage of the wave of technological innovation flourished. Our most valued commodities have gone from salt and sugar to chemicals and fuels to data and services. The regions that provide those now lead the global knowledge economy. Twenty-five hundred miles from Charleston, West Virginia, several trillion dollars of wealth was generated in Silicon Valley in addition to products that fundamentally changed the way everyone reading this book lives.

THE INDUSTRIES OF THE FUTURE

The book I know my parents or grandparents wish they had read in the 1960s would have described what globalization was going to do to the world. The book I wish I had read as I left college more than 20 years ago would have told me what the Internet and digitization were going to do to the world. This book explores the industries that will drive the next 20 years of change to our economies and societies. Its chapters are built around key industries of the future—robotics, advanced life sciences, the code-ification of money, cybersecurity, and big data—as well as the geopolitical, cultural, and generational contexts out of which they are emerging. I chose these industries not only because they are important in their own right but because they are also symbolic of larger global trends and symbiotic among each other.

"Here Come the Robots" and the "The Future of the Human Machine," chapters 1 and 2, explore how cutting-edge advances in robotics and the life sciences will change the way we work and live—with enormous, but unequal, impact on our livelihoods and our lives. As robots increasingly occupy the world alongside us, the global economy will undergo a revolution spurred by artificial intelligence and machine learning that could be as consequential for labor forces as the agricultural, industrial, and digital revolutions that preceded it. At the

same time, dramatic advances in life sciences will allow people to live longer and healthier lives than ever before—at least those who can afford it. The economic returns in robotics and life sciences will likewise be unevenly distributed between those who are well positioned to create or adopt these new breakthroughs and those who may be left even further behind. In response, societies will need to find new ways to adapt.

"The Code-ification of Money, Markets, and Trust" and "The Weaponization of Code" (chapters 3 and 4) examine how the increasing application of computer code to new areas of the economy—in the virtual and physical worlds—will transform two spheres that are traditionally state monopolies: money and force. Rapid progress often comes with greater instability. The application of code to commerce will provide new opportunities for the proverbial little guy in any part of the world to receive, hold, spend, or transfer money. At the same time, from the vantage point I had in Secretary Clinton's office and the White House Situation Room, I saw the future of an industry that has gone from being a small back-office IT function to one of the fastest-growing and most disruptive industries in the world: the weaponization of code. Together these developments may bring new opportunities, but they will also increase the ability of bad actors to cause systemic damage to the international economy.

"Data: The Raw Material of the Information Age" and "The Geography of Future Markets" (chapters 5 and 6) examine both the expansiveness that big data will allow and the constraints that geopolitics will place on the global marketplace. Whereas land was the raw material of the agricultural age and iron was the raw material of the industrial age, data is the raw material of the information age. The Internet has become an ocean of jumbled, chaotic information, but now there is a way to connect this information and draw actionable business intelligence from it. Big data is transitioning from a tool primarily for targeted advertising to an instrument with profound applications for diverse corporate sectors and for addressing chronic social problems. At the same time, the industries of the future will both be created within the current geopolitical structure and transform it. In the 20th century, the dominant divide between political systems and markets was along the axis of left versus right. In the 21st century, the dominant divide is between those that have open political and economic models and those that are closed. New competition and political necessity have created a series of hybrid models around the world, and these final two chapters explore what markets will be future sources of sustainable growth and innovation and how business leaders can make informed choices about where to invest their time and resources.

Throughout the book, we explore competitiveness—what it takes for societies, families, and individuals to thrive. Among the world's most innovative countries and businesses there is an emerging cultural consensus on how best to strengthen their most critical resource: their people. And there is no greater indicator of an innovative culture than the empowerment of women. Fully integrating and empowering women economically and politically is the most important step that a country or company can take to strengthen its competitiveness. Societies that do not overcome their negative cultural legacies regarding the treatment of women will founder in the next wave of innovation. The world's most restrictive countries have been absent from the most recent wave of innovation, and they will not be home to industries and businesses of the future without making real changes. Innovation doesn't happen in closed environments, and innovative companies will continue to steer clear of countries with regressive policies on gender.

Last, the book looks forward to explore what interventions we can make in our children's lives to best prepare them for success in a world of increasing change and competition. Parenting is the most important job that a person can have, and our children will grow up to inherit a world that looks much different from our own. We can draw from the wisdom of the innovators profiled in these pages to prepare both ourselves and our children for what's coming in the next economy—for the economy that begins now.