strategy+business

ISSUE 89 WINTER 2017

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REPRINT 17416

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Photograph by Hector Emanuel

Most people in the business world are aware of the convergence of computer and communications technology, the shift in energy from fossil fuels to renewables, and the movement toward self-driving vehicles and robot-driven manufacturing. But only a few people are thinking intensively about how all these technological changes will fit together — along with changes in advanced manufacturing, water systems, agriculture, healthcare, and education — to generate rapid, widespread growth accompanied by a dramatic reduction in ecological footprint.

This systemic approach to the industrial future is the domain of economic theorist Jeremy Rifkin. Rifkin, 72, is a longtime commentator on economic and technological issues and a lecturer in the executive education program at the University of Pennsylvania's Wharton School of Finance. He is a consultant to heads of state (including the top leadership of Germany, the president of the European Commission, and the leadership of the People's Republic of China), along with many companies (including PwC, the publisher of *strategy+ business*). And yet his logic is controversial in many business circles. He argues, for example, that both capitalism and the fossil fuel industries are hitting limits that stem from the laws of thermodynamics. Investor-based capitalism, which focuses resources for immediate returns, will inevitably be replaced by a more distributed and streamlined network-based capitalism, alongside a sharing economy governed by a high-tech global commons.

According to Rifkin, this new hybrid economic system will be made possible through the provision of solar, wind, and other renewable energy on demand, facilitated by innovations such as the Internet of Things and blockchain. In the world he envisions, the costs of producing and delivering an increasing array of goods and services will dwindle to near zero, and economies will have to learn to manage abundance — and the use of shared goods and services. These shifts will happen during the next 40 years or so, he says, unless they are cut short by the exponentially increasing dangers of climate change and species extinction.

Rifkin outlined his thesis in three successive books: *The Empathic Civilization: The Race to Global Consciousness in a World in Crisis* (Penguin, 2009); *The Third Industrial Revolution: How Lateral Power Is Transforming Energy, the Economy, and the World* (Palgrave Macmillan, 2011); and *The Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons, and the Eclipse of Capitalism* (Palgrave Macmillan, 2014). His ideas were featured in a 2017 documentary film, *The Third Industrial Revolution* (Vice Media). Two massive initiatives for which he is an advisor — the E.U.'s "Smart Europe" and China's "Internet Plus" — are, in a sense, manifestations of his world view.

Even those who do not agree with Rifkin's theory that capitalism is in the midst of a fundamental transformation must respect the exponential power of the forces he is tracking. Intelligent technology, in particular, is expanding at an ever-increasing rate, lowering costs, replacing human labor, tracking human activity, and making many new things possible — which could be the "dark net" of authoritarian surveillance or a broadening of wealth and quality of life. Rifkin sat down with *strategy+business* in late August at the Bethesda, Md.–based headquarters of his primary organization, TIR Consulting Group, to explain his arguments in greater detail.

> "It had been clear, even before the dot-com bubble collapsed in 2000, that the digital revolution was forcing down costs."

S+B: The "zero marginal cost society" concept suggests we're heading into a time of abundance that will radically change the way people live. How did you come to this idea?

RIFKIN: In the early 2000s, I was teaching in the advanced management program (AMP) at Wharton Executive Education. It had been clear, even before the dot-com bubble collapsed in 2000, that the digital revolution was forcing down fixed and marginal costs in information and communications technology in an exponential way, as described by Moore's Law.

Marginal costs are the costs of taking a product to scale, and these had already gone to near zero in media and software. Once you've paid the fixed costs to record a song, the marginal cost of streaming the music is virtually zero, whether you stream a thousand or a million copies. Newspapers, television, record labels, and the film industry discovered that they could no longer rely on their old business models, especially if they involved advertising.

S+B: But this applied only to digital media.

RIFKIN: At the time, yes. But we saw that this might soon apply to other parts of the economy as well. One major signal, for us, was the pressure IBM felt, starting in the mid-1990s. [Then CEO] Lou Gerstner, at a retreat with the company's top executives, said out loud that they had a problem. Their cash cow was the big

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mainframe computer. But as competition increased, and the price of computers continued to plummet, where would their profits come from? That led them to shift, in part, to managing information services.

In our AMP classes, I introduced the idea that the digital revolution, and dropping of marginal costs down to near zero, represented the ultimate success of capitalism. But it would also force a radical shift in the nature of the capitalist business model.

S+B: By capitalism, you mean market-based economies, governed by the laws of supply and demand, without government controls.

RIFKIN: By capitalism, I mean a particular type of market economy where the investors, owners, managers, workers, and consumers are all separate people. Capitalism of this sort is only 200 years old.

Let's step back for a moment and consider how the great economic transformations in history occur. There have been a number of them in world history, and they all have a common denominator. At a single historic moment, the same three defining technologies emerge and converge to create a new general-purpose technology infrastructure. They fundamentally change the way society manages, powers, and moves economic activity. The three technologies are new communication systems that manage economic activity more effectively; new sources of energy that power the activity more efficiently; and new modes of mobility that move the economic activity more rapidly. This changes society's spatial temporal orientation, its business models, its forms of governance, and even people's cognition and consciousness.

> "There have been a number of great economic transformations in world history, and they all have a common denominator."

For example, consider the first Industrial Revolution, which took place in the 19th century. Before then, there were very few large businesses. Most merchants owned the tools they used — the means of making, delivering, and trading goods. Then came new technologies for communications, energy, and mobility. The steam-powered printing press, which made possible cheap newspapers and mass-produced books, transformed communications. This enabled more widespread literacy; with textbooks, there could be compulsory public school systems. The invention of the telegraph annihilated space and compressed time, making possible national and even global markets. The coal-based steam engine, a new form of energy, made it possible to manage production at a much larger scale. That engine was then put on rails, giving rise to a national system of locomotive-based transportation, further speeding up the managing, powering, and moving of economic activity and the geographic expansion of markets.

These technological changes were so broad and complex that they required a new form of manage-

ment. Railroads became the first modern capitalist business corporations, with thousands of employees, vertically integrated operations, and shareholders separated from the business. Once all three technologies were in use, around 1860, modern capitalism rolled out quickly around the world. By 1900, in less than 40 years, the world had been transformed.

A second industrial revolution followed in the early 20th century. This involved the invention of the telephone and, later, radio and television; the widespread use of fossil fuels; the laying out of electricity grids; and the introduction of the internal combustion engine for road, rail, water, and air transport. The second industrial revolution's juvenile infrastructure was put in place in the United States and elsewhere between 1905 and 1929. Its growth was interrupted with the coming of the Great Depression and World War II, and it finally matured in the second half of the 20th century across the industrial world.

S+B: And by the early 2000s, you were saying that way of life was obsolete.

RIFKIN: We saw that the productivity potential of the second industrial revolution technology infrastructure had run its course. Meanwhile, a dramatic reduction in fixed and marginal costs had already occurred in computers and communications, and would probably occur elsewhere as well. And as this happened, it would change the economy so that neoclassical economic theory would no longer suffice to describe it.

The world was entering a third industrial revolution — a digital revolution. [Note: Although the numbers differ, what Rifkin calls the third industrial revolution and the broad technological shift known as "Industry 4.0" are roughly the same movement.] In a digitally connected society, the marginal costs of an increasing number of goods and services would fall to near zero. This would force a fundamental change in prevailing business models: from markets to networks, from ownership to access, from workers to "prosumers" [individuals who produce as well as consume goods and services distributed on the Web], from sellers and buyers to providers and users, and from consumerism to sustainability — and the second industrial revolution's economies of scale would no longer apply. The communications part of it had already happened: Inexpensive computers and the Internet existed, and the smartphone had just been invented. It took a while to see that the same phenomenon could occur in the world of atoms, and dramatically reduce the cost of energy, mobility, and other goods and services.

The Next Infrastructure

S+B: So when you say "third industrial revolution," what change are you referring to?

RIFKIN: A new technological infrastructure is gradually coming together, brought on by digitization. The process began with the maturation of the communications Internet over the past 25 years. Now this is converging with a second Internet, this one for renewable energy. It's a new digital power grid, stretching across continents, which allows millions of people to produce their own wind and solar electricity and send their excess power generation back into the system. Both of these Internets will converge, during the next decade, with an emerging digitized mobility Internet composed of increasingly autonomous electric and fuel-cell vehicles operated by near-zero marginal cost renewable energy on smart road, rail, water, and air systems. These three systems will allow people to share communication, energy, and mobility partially in the capitalist market and partially in the emerging sharing economy.

S+B: Where will this shift happen first?

RIFKIN: It's already happening in some places. Germany has been quietly building out the necessary infrastructure for the past 10 years. When Angela Merkel became chancellor in 2005, she asked me to advise her on growing the German economy. She and I discussed the potential of transforming Germany into a third industrial revolution paradigm. Almost immediately, she and her colleagues resolved to be-

come world leaders in the third industrial revolution.

Since then, Germany has been working on all three fronts: the digitization of communications, renewable energy, and mobility. I have been working closely with senior government officials there, including president Frank-Walter Steinmeier and vice chancellor and economy minister Sigmar Gabriel. Under the plan they put in place, one-third of German electricity is now produced through renewable energy, at near-zero marginal costs. Installing solar and wind technologies is tremendously labor intensive, at least during this transition. Germany has created hundreds of thousands of net jobs this way, and now there are more jobs in renewable energy than in the rest of the energy industry combined.

On a parallel track, I have worked with three presidents of the European Commission — Romano Prodi, José Manuel Barroso, and the current president, Jean-Claude Juncker — in the conception and deployment of a smart digital third industrial revolution across all 28 member states of the European Union. In February 2017, I joined Maroš Šefčovič, the vice president of the European Commission in charge of the E.U. Energy Union and Smart Europe, and Markku Markkula, the president of the European Committee of the Regions, in announcing the launch of the Smart Europe initiative. A €631 billion [US$744 billion] kitty for investment — the Juncker Fund — will now be partially available for its deployment.

The other center of activity is China. When President Xi and Premier Li came into office, Premier Li published his official biography, which mentioned that he had read [my book] *The Third Industrial Revolution* and had instructed the central government to pay close attention to the narrative and proposals outlined in the book. President Xi and Premier Li realized that their country had been locked out of the first Industrial Revolution and much of the second, and they didn't want to lose out on the third. Shortly after the first of several formal visits I had with Chinese leaders, the chairman of the national electric power grid announced an [US]$82 billion commitment to digitize the state electric power grid in the current Five-Year Plan. Millions of Chinese people can produce their own solar and wind power, and use it locally or sell it back to the grid. With the Belt and Road project, they're moving the same technologies to other countries. China calls this digital transformation the Internet Plus revolution, which is similar to the Smart Europe initiative. Of course, China is still one of the world's largest users of fossil fuels, but that is rapidly changing.

Parts of the U.S. are also moving in this direction, without much government involvement: California, Oregon, Washington state, New York, New England, and the San Antonio–Austin area in southeastern Texas. There are wind farms in the prairie states and many large companies and small entrepreneurial startups, all hoping to lead the transition.

The payback for renewable energy is much more rapid than people think. The fixed costs — materials and installation — have gone down exponentially. In 1979, the fixed cost of producing one watt of solar electricity was $79. As of August 2017, it's 55 cents. By 2020, it will be 35 cents. The viability of the technology is just now reaching a tipping point. As for the marginal costs, there aren't any. The sun and wind haven't sent us a bill.

S+B: What about mobility and communications?

RIFKIN: Already, millions of people use car-sharing networks as their primary mode of transportation. Millennials don't want to own automobiles. They want access to mobility in car-sharing networks. Meanwhile, the marginal costs of autonomous, self-driving electric vehicles operating with near-zero marginal cost renewable energy will plummet. Drones will also operate with near-zero marginal costs. Today, there are about a billion cars, buses, and trucks, and they are the third major cause of global warming emissions, after buildings and beef production and consumption and related agricultural practices. We'll likely eliminate 80 percent of vehicles in the world in the next two generations as we shift to car and truck sharing [via] provider–user networks.

The cars and trucks that are left will become, in effect, rolling, mobile distributed data centers outfitted with sensors that pick up and share information on traffic, weather conditions, warehouse availability, and logistics. Daimler has already quietly outfitted more than 400,000 of its motor trucks with sensors. This will increase aggregate efficiency and productivity, while dramatically reducing ecological footprint.

> "In 1979, the fixed cost of producing one watt of solar electricity was $79. As of August 2017, it's 55 cents. By 2020, it will be 35 cents."

The Key to Productivity Growth

S+B: Doesn't this contradict what people like Robert Gordon and Erik Brynjolfsson have been saying about productivity growth — that it is not likely to pick up again?

RIFKIN: They haven't taken aggregate efficiency into account. Aggregate efficiency is the ratio of potential work to the actual useful work that gets embedded into a product or service. The higher the aggregate efficiency of a good or service, the less waste is produced in every single conversion in its journey across the value chain.

A few economic researchers, like physicist Reiner Kümmel at the University of Würzburg and economist Robert Ayres at INSEAD, have reconsidered productivity in recent years. Traditional economics says you increase productivity by investing more capital in better machines and by providing better-performing workers, all of which reduces the fixed and marginal cost of production. But these factors account for only about 14 percent of productivity. Much of the rest of productivity is accounted for by the improvement in aggregate efficiency in the managing, powering, and moving of economic activity.

Aggregate efficiency works the same way in economic production as it does in nature. When a lion chases down an antelope and kills it, only about 10 to 20 percent of the entire energy in the antelope gets embedded into the lion; the rest is heat lost in the transition. So the lion's aggregate efficiency is only 10 to 20 percent. If it could consume more of its prey's energy, or use less of its own in the hunt, the lion would gain productivity as a predator.

Economists are now learning that aggregate efficiency is a critical determiner in productivity growth. In the past, economists have missed this because they have not been trained in thermodynamics; chemists, engineers, biologists, and architects get it.

When the second industrial revolution began around 1905, there was about 3 percent aggregate efficiency in the U.S. production of goods and services. Mass production methods dramatically improved this level, and productivity rose as a result. But there were limits to the efficiency of 20th-century telecommunications, fossil fuel–based energy systems, and internal combustion–driven transportation. By the beginning of the 21st century,

the U.S. was up to around 13 percent aggregate efficiency; Germany had reached 18.5 percent; and Japan led the world at 20 percent aggregate efficiency. That was the ceiling, and productivity growth stagnated. Businesses that plug into the second industrial revolution infrastructure can no longer significantly increase their aggregate efficiency and productivity in managing, powering, and moving their goods and services through their value chains.

Now, with the digital third industrial revolution more fully under way, aggregate efficiency is about to rise again — perhaps exponentially this time. Two factors are the vastly reduced costs of communication, energy, and transport that we talked about. Another is the Internet of Things. The cost of sensors and identification chips is, for the first time, dropping low enough to allow us to embed them in trillions of devices: thermostats, assembly lines, appliances, warehouse equipment, and more, all gathering data. With the IPv6 protocol, those devices can be interconnected through the Internet. When intelligent technology is embedded in homes, offices, factories, and infrastructure, everyone will have a transparent picture of all the economic activity flowing through the economy, with the ability to mine it and use predictive analytics to improve thermodynamic efficiency and productivity while reducing the ecological footprint of economic activity.

The impact will be immense. For instance, an improvement of just 1 percent in aviation engine fuel efficiency, which GE posits as a baseline for its new systems, would save $30 billion over 15 years. The intelligent value chain would be continually learning how to create, use, upgrade, recycle, and reuse physical goods at an ever lower cost. We'll have an economy of partial abundance, full of many nearly free products and services provided at near-zero marginal cost.

S+B: What would living in that economy of abundance be like?

RIFKIN: We're witnessing the birth of a new economic system: a hybrid of the existing capitalist structure and the sharing economy. Most of the goods and services that [make up our] quality of life will be much less expensive. It will be easier to broaden prosperity, without having to fight over scarce resources, in part because it will be much easier to make the most of the resources we have.

Cooperatives, free services, and app-based resource-sharing enterprises will crowd out some — but not all — of the incumbent corporations that depend on fixed-cost business models. We already saw this with digital communications. Whole industries were disrupted: music, television, newspapers, publishing, magazines, educational media. But new businesses emerged, and not just the major platforms like Facebook, Google, and Amazon. Millions of individuals are producing and selling or sharing virtual goods, like music, videos, and writing, at near-zero marginal production cost, using blogs and social media to find audiences. Millions of students are taking massive open online college courses and getting college credits. The most notable is Jimmy Wales's experiment with Wikipedia: It's the sixth-largest website in the world, operated with $50 million in donations a year. For the first time in history, the knowledge of the world is being democratized: People from all walks of life have constructed it in a peer-reviewed platform, with accuracy at least equal to that of top-down encyclopedias. When anyone puts something up on Wikipedia, there are people crawling all over it within hours, checking

their sources or amplifying their text with additional information.

Investor capitalism won't disappear; it will live side by side with the sharing economy. In the emerging era, the cooperative form of business is being reinvigorated because of the lateral scaling advantages made possible by a digitally interconnected global economy with near-zero marginal cost. There were already successful cooperatives around the world, many of them dating back to the early 20th century. A billion and a half people work in them, in industries like agriculture, food production, housing, banking, and energy. They have new life now that there are IT-based tools, such as blockchain, that make it easier to collaborate, and because of the scaling advantages made possible by the digitally interconnected global economy.

The four largest German power companies — EnBW, RWE, E.ON, and Vattenfall — dominated the power and electricity market for years. But together, they own only about 5 percent of all installed capacity of renewable energy in the country. The rest is generated by small companies and cooperatives: democratically managed enterprises in which the profits go to the members. At least two of the big four power companies in Germany are becoming distributors and aggregators of renewable energy that the small players generate across the country. These new electricity cooperatives — some representing farmers, others run by small business groups or urban neighborhood associations — have received low-interest loans from the banks and put up solar and wind generation installations. None of these companies defaulted on their loans. Instead, they sold their extra energy back to the power grid. Cooperatives scale more efficiently than the large incumbent power companies. There are similar electric power cooperatives in the United States.

> "We're witnessing the birth of a new economic system: a hybrid of the existing capitalist structure and the sharing economy."

Abundance and Its Discontents

S+B: What effect will this have on today's energy and transportation industries?

RIFKIN: The legacy fossil fuel industries, and the countries that depend on them, will suffer. According to a recent study by Citibank, the energy industry and power and transmission companies today are sitting on potentially $100 trillion in stranded assets. These include exploration rights, leases, and infrastructure for the extraction of fossil fuel that will be underpriced by renewables. Countries like Saudi Arabia and the Emirates, with oil-based economies, see the disruption coming. So do some of the major oil companies. Other players in the energy industries are simply in denial. But for those that are willing to adapt, there will be some time. We're not leaving the second industrial revolution entirely tomorrow morning. This is a

30- to 40-year transition stretching over two generations.

In the end, the economy may no longer be controlled by a small group of centralized, global, vertically integrated companies. The first and second industrial revolution infrastructures were centralized, proprietary, and vertically scaled because the communication, energy, and transport technologies worked best that way. By contrast, the coming infrastructure of 5G communication, renewable energy, and automated mobility works best if it's distributed, open, transparent, crowd-sourced, and laterally scaled. The more users on the network, the more everyone benefits. With any attempt to monopolize, control, or centralize it, the infrastructure loses aggregate efficiency and productivity. Even today's giant Internet platforms, if they become too centralized, will be vulnerable to others coming in and taking their place.

We'll see a similar kind of change in education. The public school system was a great leap forward in the 19th century, but it was introduced to prepare a generation for the first industrial revolution of factory and office employment, and then was only slightly upgraded for the second industrial revolution. A school designed for that time is a microcosm of a factory. The teacher instructs, and the students are supposed to memorize the knowledge and recite it back. Every 50 minutes a bell rings and they move to the next spot on the line. They're being trained to be efficient automatons operating machines. If the students share information, and help each other, it's called cheating.

Today, millennials have an alternative. Outside the classroom, they're all learning together on their smartphones. They're crowdsourcing, playing online games together, and sharing their knowledge. We need to move toward a new kind of school that recognizes this collaborative interconnectivity.

> "In the end, the economy may no longer be controlled by a small group of centralized, global, vertically integrated companies."

One model for this change is in Hauts-de-France — the rust belt of France, where its coal, steel, and auto industries are based. Beginning in 2010, our global consulting team began working with the region to revitalize its economy, working alongside the government, the business community, and civil society, with several thousand people participating in scores of committees and projects. They are transforming old mining towns, retrofitting them with solar and wind power sources, and starting entrepreneurial enterprises.

The region brought together seven universities and more than 250 secondary schools in a consortium to think in terms of digital education. They didn't eliminate departments, but all the departments now teach in an interdisciplinary fashion, with multiple perspectives. The students work in teams, and they have to teach one another, with the faculty operating as guides. They also ratcheted up service learning, so that students at all levels work outside in the communities, and have to teach and learn collaboratively with the community businesses and neighborhoods. There is a robust level of social entrepreneurialism involving students, teachers, and their neighborhoods in ways that generate more positive community value.

S+B: You've portrayed the upside, but what about the downsides?

RIFKIN: Although the digital third industrial revolution could bring about a more democratic and ecological era, it is by no means guaranteed. I'm not a utopian in regard to technology. Indeed, I've been critical of some technologies over the years. There are going to be many political struggles along the way. For example: How do we ensure data privacy when everyone's connected?

How do we prevent cybercrime and cyberterrorism? And how do we prevent Internet companies, the big ones, from monopolizing the platform for commercial purposes and exploiting the information they gather? Increasingly, members of the millennial generation are aware that their personal information is commodified and sold to third parties, which incorporate it into algorithms and use it for marketing and other purposes. Authoritarian governments can use that same information to control what people do politically.

These are qualitatively big issues. In Europe now, policymakers are recognizing that these issues of the dark net are as formidable as the possibilities are bright, and they will have to spend at least 50 percent of their regulatory capacities managing them. It's naive to think that companies like Google, Facebook, Amazon, and Twitter can maintain their current practices without regulation. The battles over this have already started.

And the biggest shadow in the room is climate change. Most scientists had thought that we had another 100 years before facing a significant crisis, but we didn't fully anticipate the feedback loops brought on by global warming emissions — the more the Earth warms, the more the process of climate change accelerates. We probably have less than 30 years to effectively exit a carbon-based civilization.

The most recent indicators of change have scared the living daylights out of me. For every one degree rise in the temperature of the planet brought on by global warming emissions, the atmosphere is absorbing 7 percent more precipitation from the ground and the oceans, leading to more concentrated precipitation in the clouds and more extreme and unpredictable water events — blockbuster winter storms, dramatic spring flooding, prolonged summer droughts and wildfires, and category three, four, and five hurricanes. Our ecosystems cannot catch up to a runaway exponential curve in the water cycles and are collapsing in real time, taking us into the sixth extinction event of life on Earth over the course of the next half century. Even in a world of abundance, climate change is the dark shadow that could foreclose opportunities for present and future generations and for life itself on Earth.

Fortunately, the third industrial revolution is based on post-carbon technology. Moreover, it's inclined toward a highly diverse and distributed infrastructure. The more diverse, redundant, and distributed the networks and systems are, the more resilient the infrastructure is, and the less vulnerable it is to cybercrime, cyberterrorism, or natural disasters from climate change.

But there may not be enough time to avoid the abyss. The transition would have to take place quickly. We would need to make the shift in 30 to 40 years. As I said, we know it's possible. The second industrial revolution infrastructure was installed across much of the United States in less than 40 years. We could, if highly motivated and passionately committed, do something similar across the world over the course of the next 30 years by using the third industrial revolution to transition into a more just and ecologically sustainable civilization. ✚

Reprint No. 17416

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