

Welcome to the Third Industrial Revolution

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What will the scale-up of the internet of things, the rising sharing economy and a zero marginal cost society mean for civilization? Nothing short of historic.

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Capitalism is giving birth to a progeny. It is called the sharing economy on the Collaborative Commons. This is the first new economic system to enter onto the world stage since the advent of capitalism and socialism in the early 19th century, making it a remarkable historical event. The Collaborative Commons is already changing the way we organize economic life, offering the possibility of dramatically narrowing the income divide, democratizing the global

economy and creating a more ecologically sustainable society.

Like every parent-child relationship, the two economic systems more often cooperate, but on occasion are at odds. And while the capitalist parent will need to nurture its child and allow it to mature, the child will also transform the parent in this unfolding relationship. We are already witnessing the emergence of a hybrid economy—a part capitalist market and part sharing economy. To the extent that capitalism can create new business models and practices that will support the development of the sharing economy, it will prosper along with its offspring.

What's precipitating the great economic transformation is the unanticipated rise of the near zero marginal cost phenomenon, brought on by the digitization of everything. Private enterprises are continually seeking new technologies to increase productivity and reduce the marginal cost of producing and distributing goods and services so they can lower prices, win over consumers and secure sufficient profit for their investors. (Marginal cost is the cost of producing additional units of a good or service if fixed costs are not counted.) Economists never envisioned, however, a technology revolution that might unleash "extreme productivity," bringing marginal costs toward zero, making communication, energy and transportation, as well as many other physical goods and services, potentially very cheap in the conventional marketplace—or nearly free, abundant and no longer subject to market exchanges in an emerging sharing economy. That's now beginning to happen.

The near zero marginal cost phenomenon has already disrupted the "information goods" industries over the past decade as millions of consumers turned into "prosumers" and began using the Internet to produce and share their own music via file sharing services, their own videos on YouTube, their own knowledge on Wikipedia, their own news on social media, and even their own e-books, all for nearly free. Meanwhile, 6 million students are currently enrolled in free massively open online courses (MOOCs) that operate at near zero marginal cost and are taught by some of the most distinguished professors in the world. The near zero marginal cost phenomenon brought the music industry to its knees, shook the film and television industries, forced newspapers and magazines out of business, crippled the book publishing market and forced universities to rethink their business model.

While many traditional industries suffered, the zero marginal cost phenomenon also gave rise to thousands of Internet enterprises that reaped handsome profits by creating the applications and aggregating the networks that allow the emerging sharing economy to flourish.

Economists acknowledge the powerful impact near zero marginal cost has had on the information goods industries, but until recently they have argued that the productivity advances made possible by the digital economy would not pass across the firewall from the virtual world to the brick-and-mortar economy of energy, transportation, and physical goods and services. That firewall has now been breached. A new Internet of Things (IoT) is evolving that will allow conventional business enterprises, as well as millions of prosumers, to make, store and distribute their own renewable energy on a digital Energy Internet; share vehicles on an automated, GPS-guided and soon driverless Transportation and Logistics Internet; and manufacture an increasing array of 3-D-printed physical products and other goods and services—at very low marginal cost in the market exchange economy, or at near zero marginal cost in the sharing economy—just as they now do with information goods.

Connecting everything and everyone through the Internet of Things offers enormous economic benefits. It also raises risks and challenges, not the least of which are guaranteeing network neutrality, protecting personal privacy, ensuring data security, and thwarting cybercrime and cyberterrorism. Every government will need to address these critical issues in the years ahead.

The Internet OF Things

To grasp the enormity of the economic change taking place, we need to understand the technological forces that have given rise to new economic systems throughout history. Every great economic paradigm requires three elements, each of which interacts with the other to enable the system to operate as a whole: a communication medium, a power source and a transportation mechanism. Without communication, we can't manage economic

activity. Without energy, we can't power economic activity. Without transportation and logistics, we can't move economic activity across the value chain. Together, these three operating systems make up what economists call a general purpose technology platform.

In the 19th century, steam-powered printing, the telegraph, and abundant coal and locomotives on national rail systems meshed in a seamless general-purpose technology platform that gave rise to the First Industrial Revolution. In the 20th century, centralized electricity, the telephone, radio and television, cheap oil and internal combustion vehicles on national road systems converged to create an infrastructure for the Second Industrial Revolution.

Now, the Communication Internet is converging with the digitized renewable Energy Internet and the digitized Transportation and Logistics Internet, creating an Internet of Things platform for a Third Industrial Revolution. Sensors are being attached to every device, appliance, machine and contrivance, connecting everything with every human being in a digital neural network that extends across the entire economy. Already, 14 billion sensors are attached to resource flows, warehouses, road systems, factory production lines, the electricity transmission grid, offices, homes, stores and vehicles. They continually monitor their status and performance and feed data back to the Internets.

In this expanded digital economy, private enterprises connected to the Internet of Things can use big data and analytics to develop predictive algorithms that can speed efficiency, increase productivity, and dramatically lower the marginal cost of producing and distributing products, making businesses more competitive in the global marketplace. The marginal cost of producing some goods and services in the digital era will even approach zero, allowing millions of prosumers connected to the Internet of Things to share what they have made with others, for nearly free, in the growing sharing economy.

The distributed, peer-to-peer nature of the IoT platform allows millions of disparate players—small and midsize businesses, social enterprises and individuals—to come together and produce and exchange goods and services directly with one another, eliminating the remaining middle men that kept marginal costs high in the Second Industrial Revolution. This fundamental technological transformation in the way economic activity is organized and scaled portends a great shift in the flow of economic power from the few to the multitudes and the democratization of economic life.

For example, the bulk of the energy we use to heat our homes, run our appliances, power our businesses, drive our vehicles and operate every part of the global economy will be generated at near zero marginal cost and be nearly free in the coming decades. That's already the case for several million early adopters who have transformed their homes and businesses into micro-power plants to harvest renewable energy on-site. In Germany, over 1 million homes and small businesses are generating 27 percent of the energy powering Germany. After the fixed costs for the installation of solar and wind are paid back—often as little as two to eight years—the marginal cost of the harvested energy is nearly free. Unlike fossil fuels and uranium for nuclear power, in which the commodity itself always costs something, the sun collected on rooftops and the wind travelling up the side of buildings are free. The Internet of Things will enable hundreds of millions more prosumers to generate their own green electricity on-site,



monitor their electricity usage in their buildings, optimize their energy efficiency and share surplus green electricity with others on the Energy Internet.

A growing number of electricity-generating companies are coming to grips with the new reality of democratized energy and are changing their business model to accommodate it. In the future, their income will increasingly rely on managing their customers' energy use. The electricity companies will mine big data across each of their clients' value chains and use analytics to create algorithms and applications to increase their aggregate efficiency and productivity, and reduce their marginal costs. Their clients, in turn, will share the efficiency and productivity gains back with the electricity companies in what are called "performance contracts." In short, power companies will profit more from managing energy use more efficiently and selling less rather than more electricity.

In these ways and more, the transition to a fully digital economy results in a leap in productivity far beyond the productivity gains achieved by the Second Industrial Revolution. During the period from 1900 to 1980 in the United States, aggregate efficiency—the ratio of useful to potential physical work that can be extracted from materials—steadily rose along with the development of the nation's infrastructure, from 2.48 percent to 12.3 percent. The aggregate efficiency leveled off in the late 1990s at around 13 percent with the completion of the Second Industrial Revolution infrastructure. Despite a significant increase in efficiency, which gave the United States extraordinary productivity and growth, nearly 87 percent of the energy we used in the Second Industrial Revolution was wasted during transmission.

Even if we were to upgrade the Second Industrial Revolution infrastructure, it's unlikely to have any measurable effect on efficiency, productivity or growth. Fossil fuel energies have matured and are becoming more expensive to bring to market. Furthermore, the technologies designed and engineered to run on these energies, like the internal-combustion engine and the centralized electricity grid, have exhausted their productivity, with little potential left to exploit.

New studies show that with the shift to an IoT platform, it is conceivable to increase aggregate efficiency to 40 percent or more in the next 40 years. A General Electric study published in November 2012 concluded that the efficiency gains and productivity advances brought on by a smart industrial Internet could resound across virtually every economic sector by 2025, impacting "approximately one-half of the global economy." In dollar terms, the Internet of Things could generate \$14.4 trillion in cost savings and revenue by 2022, according to Cisco Systems forecasts.

"Do it Yourself" Manufacturing

Virtually every industry will be transformed by the IoT platform and the Third Industrial Revolution. For example, a new generation of micromanufacturers are beginning to plug in to the insipient IoT, dramatically increasing their productivity while reducing their marginal costs to near zero, enabling them to outcompete the formerly invincible global manufacturing firms, organized around vertically integrated economies of scale. It's called 3-D printing.

Printers are already producing products from jewelry and airplane parts to human prostheses. Cheap printers are being purchased by hobbyists; the consumer is giving way to the prosumer.



Three-dimensional printing differs from conventional centralized manufacturing in several important ways. To begin with, most of the software used to program and print physical products is open source, allowing prosumers to share new ideas with one another in do-it-yourself hobbyist networks. The open design concept conceives the production of goods as a dynamic process in which thousands—even millions—of players learn from one another by making things together. The elimination of intellectual-property protection also significantly reduces the cost of printing products, giving the 3-D printing enterprise an edge over traditional manufacturing enterprises, which must factor in the cost of myriad patents. Most 3-D printers are using recycled paper, plastic and metal objects as filament, further reducing the material cost of manufacturing the final product.

Plugging into an IoT infrastructure at the local level gives the small manufacturers one final, critical advantage over the vertically integrated, centralized enterprises based on the 19th and 20th centuries: They can power their vehicles with renewable energy whose marginal cost is nearly free, significantly reducing their logistics costs along the supply chain and in the delivery of their finished products to users.

The new 3-D printing revolution is an example of “extreme productivity.” The distributed nature of manufacturing means that anyone—and eventually everyone—can access the means of production, making the question of who should own and control the means of production increasingly irrelevant for a growing number of goods.

Many global manufacturing enterprises will continue to flourish, but they will be fundamentally transformed by the democratization of manufacturing. While much of the manufacturing will be done by small and medium enterprises that can take advantage of the increased energy efficiencies and productivity gains of lateral economies of scale, the giant manufacturing enterprises will find value in aggregating, integrating and managing the marketing and distributing of products.

A Leap Into the Sharing Economy

While the developing digital infrastructure is making the traditional capitalist market more productive and competitive, it is also spurring the growth of a new economic model: the sharing economy. In the sharing economy, social capital is as vital as finance capital, access is as important as ownership, sustainability supersedes consumerism, cooperation is as crucial as competition, and “exchange value” in the capitalist market place is increasingly supplemented by “shareable value.” Millions of people are already transferring bits and pieces of their economic life to the global Collaborative Commons. Prosumers are not just producing and sharing their own information, entertainment, green energy and 3-D-printed goods at near zero marginal cost. They are also sharing cars, homes and even clothes with one another via social media sites and cooperatives.

About 40 percent of the U.S. population is actively engaged in the sharing economy. Millions of Americans are now using carsharing services like [Uber](#), [Lyft](#) and [RelayRides](#). Each car share vehicle eliminates 15 personally owned cars. It’s very likely that future generations will never own vehicles again. The privately owned automobile, the centerpiece of the capitalist marketplace during the Second Industrial Revolution, is falling victim to the distributed, laterally scaled opportunities of car sharing on a rising Collaborative Commons better suited to optimize the general welfare of society. The disruptive impact on the global transportation industry is going to be profound and far-reaching.



The long-term transition from ownership of vehicles to access to mobility in driverless vehicles on smart road systems will fundamentally alter the business model for the transportation industry. While the big auto manufacturers around the world will produce fewer vehicles over the course of the next 30 years, they will increasingly reposition themselves as aggregators of the global automated Transportation and Logistics Internet, managing mobility services and logistics.

Concurrently, millions of apartment dwellers and homeowners are sharing their dwellings with millions of travelers, using online services like [Airbnb](#) and [Couchsurfing](#). In New York City alone, Airbnb's 416,000 guests between 2012 and 2013 resulted in 1 million lost room nights, delivering a devastating blow to the hotel industry.

Recent surveys underscore the broad economic potential of the Collaborative Commons. When asked to rank the advantages of a sharing economy, respondents listed saving money at the top of the list, followed by impact on the environment, lifestyle flexibility, practicality of sharing, and easy access to goods and services. As for the emotional benefits, respondents ranked generosity first, followed by a feeling of being a valued part of a community, being smart, being more responsible and being a part of a movement.

How likely is it that the sharing economy will play an ever larger role in the economic life of society in the coming decades? According to an opinion survey conducted by Latitude Research, 75 percent of respondents forecasted that their sharing would increase in five years. Many industry and media analysts agree with these optimistic forecasts. Time magazine declared collaborative consumption to be one of its "10 ideas that will change the world."

In a fully digitized economy, extreme productivity, brought on by the optimization of aggregate efficiency and the reduction of marginal cost toward zero across every sector of the economic value chain, decreases the amount of information, energy, material resources, labor and logistics costs necessary to produce, distribute and recycle economic goods and services, once fixed costs are absorbed. The shift from ownership to access also means a significant reduction in the number of new products sold, resulting in fewer resources used up and less global warming gases emitted into the earth's atmosphere.

In other words, the headlong push to a near zero marginal cost society is the most ecologically efficient economy achievable. Near zero marginal cost is the ultimate benchmark for establishing a sustainable future for the human race on earth. The Internet of Things infrastructure enables humanity to create a low-carbon society and mitigate climate change.

Triggering a Third Industrial Revolution

Erecting the IoT infrastructure for the Third Industrial Revolution will require a significant investment of public and private funds, just as was the case in the first two industrial revolutions. The financing is within reach, but will require a reprioritization of currently allocated infrastructure funds. For example, the European Union invested 740 billion euros in 2012 on infrastructure-related projects, much of it to shore up an outmoded Second Industrial Revolution platform. If just 25 percent of these funds were redirected and earmarked in every region of the European Union to assemble the IoT infrastructure, the digitized economy could be realized between now and 2040.

The communication network in every country will have to be upgraded with the inclusion of universal broadband and free Wi-Fi. The energy infrastructure will need to be transformed from fossil fuel and nuclear power to renewable energies. Millions of buildings will need to be retrofitted and equipped with renewable energy harvesting installations. Hydrogen and other storage technologies will have to be built into every layer of the infrastructure to secure intermittent renewable energy. The electricity grid will have to be transformed into a smart digital [Energy Internet](#) to accommodate the flow of energy produced by millions of green micropower plants. The transportation and logistics sector will have to be transformed into an automated GPS-guided driverless network running on smart roads and rail systems. The introduction of electric and fuel cell transportation will require millions of electric vehicle charging stations, connected to the Energy Internet. Smart roads, equipped with millions of sensors feeding real-time information on traffic flows and the movement of freight will have to be installed.

The establishment of the Third Industrial Revolution infrastructure will necessitate the active engagement of virtually every commercial sector, spur commercial innovations, promote small and midsize enterprises, and employ millions of workers over the next 40 years. The power and electricity utilities; transportation and logistics; and the telecommunication, construction, electronics, manufacturing, biotech and retail industries will all need to be brought into the process. Many of today's leading companies, as well as new commercial players, will help establish and manage the Internet of Things platform, allowing millions of others—small, medium and large-sized businesses, nonprofit enterprises, and prosumers—to produce and use renewable energy, transportation and logistics, and a panoply of other goods and services at low marginal cost in the exchange economy or at near zero marginal cost in the sharing economy.

The alternative—staying entrenched in the sunset of the Second Industrial Revolution with fewer economic opportunities, a slowing of GDP, diminishing productivity, rising unemployment and an ever-more polluted environment—is unthinkable, and would set humanity on a long-term course of economic contraction and decline in the quality of life of its citizenry.

We are on the cusp of a promising new economic era with farreaching benefits for humankind. What's required now is a global commitment to phase in the platform of the Internet of Things to facilitate the transition to a digitized zero marginal cost society if we are to create a more just, humane and ecologically sustainable society.

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