The United States and Europe have been at the forefront of the Industrial Revolutions over the last two and a half centuries. Almost all Asian countries, except Japan, were latecomers to these revolutions. Nevertheless, many of them, including China, South Korea, Singapore, Hong Kong, Taiwan, India, Indonesia, and Malaysia, made significant progress by the end of the Third Industrial Revolution. What follows is a brief depiction of the involvement of Japan; the “Asian Giants,” China and India; and the four “Asian Tigers,” South Korea, Singapore, Hong Kong, and Taiwan, in the first three Industrial Revolutions and a more extended discussion of the role several Asian nations are taking in what at least one scholar has called the Fourth Industrial Revolution.

THE FIRST INDUSTRIAL REVOLUTION
(Mid-Eighteenth Century through Mid-Nineteenth Century)
The First Industrial Revolution began in Britain with the invention of weaving machines, most famously the spinning jenny, in 1764 for the textile industry and expanded through other transformative inventions such as the steam engine, railroads, and machine tools.1 During this period, the Indian subcontinent in Asia became part of the British colonial empire, which benefited greatly from India’s natural resources. The British also dominated trade with China through their control of ports in Singapore and Hong Kong. The gross domestic products (GDP) of India and China declined, while the GDPs of Western Europe and the United States increased (see Figure 1).

THE SECOND INDUSTRIAL REVOLUTION
(Late Nineteenth Century through Early Twentieth Century)
The Second Industrial Revolution took place in Europe and the United States between the late nineteenth and early twentieth centuries. New inventions, including the use of interchangeable parts, the Bessemer steel production process, and the assembly line for mass production, helped significantly increase manufacturing output and production systems.

Japan was a latecomer to the First Industrial Revolution and much more of a player in the second. During the Meiji period (1868–1912), the Japanese government eventually created state-led capitalism, assisting industrial and business growth in a variety of ways. By the early twentieth century, Japan, in addition to becoming an imperial power that controlled what is now Taiwan, as well as Korea, was creating a substantial industrial sector. World War I was a tremendous boon for Japan’s economy, with exports more than quadrupling, and shipbuilding and steel production becoming important. New manufacturing techniques, such as assembly lines, and other scientific management procedures were introduced in factories, and the nation experienced financial growth and prosperity. Although the economy was devastated in World War II, due to a variety of factors, including an educated and well-disciplined workforce and American pro-growth Occupation policies, Japan experienced the first Asian economic “miracle.”

THE THIRD INDUSTRIAL REVOLUTION
(Mid–Late Twentieth Century)
The development of digital computing, personal computing, and the Internet catalyzed the Third Industrial Revolution.2 The USA, (West) Germany, and Japan led industrial growth and development during this revolution, exemplified by visionaries such as Bill Gates and Steve Jobs. The US, enjoying both technological and financial dominance, had the world’s largest GDP. Japan successfully rebuilt its economy so that its world GDP rank grew from fifth place in 1960 to second place in 2000.3 Internet and computer technology, high-speed air travel, and satellite communications helped industries expand globalization. More multinational companies (MNCs) moved to Asian countries—basing manufacturing operations within Asia, where labor and material costs were significantly lower. It created opportunities for China, India, and other Asian nations to collaborate and share knowledge with companies and governments from developed countries and improve their own industries.

During the Third Industrial Revolution, Hong Kong, Taiwan, Singapore, and South Korea—the four Asian Tigers—emerged as highly successful economies challenging and exceeding Japan. Taiwan began the process of rebuilding its economy after World War II. American help and domestic policies caused a surge in exports from US $174 million in 1960...
to US $1.56 billion in 1970. In the 1970s, Taiwan embraced advanced technologies such as microelectronics and personal computers. By the early 1990s, it was one of the world's largest exporters of personal computers. South Korea, like Taiwan, but even poorer after the Korean War, began significant economic development during the 1960s. By the turn of the century, South Korea was one of the world's leading economies, with a gross national product (GNP) that grew from US $2.3 billion in 1962 to US $295 billion in 1992. Hong Kong, always an entrepot, created a booming textile and light manufacturing industry sector, and its world GDP grew from forty-fourth in 1960 to twenty-fifth in 2000. Singapore has also promoted programs of economic restructuring, modifying education policies to expand technology and computer education, and offering financial incentives to industrial enterprises.

By the end of the Third Industrial Revolution, China had become the manufacturing center of the world, exporting an impressive quantity of items such as toys, consumer products, and clothing, and enjoyed the world's seventh-largest GDP. After its 1947 independence, the Indian government adopted a socialist and protectionist path, but in 1991, after decades of poor economic performance, government policymakers initiated market competition and globalization. The policy shift incentivized private business and industry to substantially increase production of goods and services. India's exports of high technology products, particularly software, continually grew. Indian workers with broad English-language and technological skills were competitive in the global service labor market; India became a hub for Western call centers and, thanks to improved annual growth rates, was the world's thirteenth-largest GDP by 2000.

The emerging economies of Asia in part owed their successes to the consistent and careful planning of their governments, which in most cases were authoritarian but shared the goal of reducing poverty through industrial development, encouraging and supporting private enterprises until they were self-sufficient. International institutions such as the World Bank and International Monetary Fund (IMF), along with wealthier nations like Japan and the United States, provided much-needed financial investment and technological knowledge, too. Other emerging countries in Asia, such as Malaysia and Indonesia, also achieved upward mobility in the world's GDP rankings during the Third Industrial Revolution.

**THE FOURTH INDUSTRIAL REVOLUTION**

The Fourth Industrial Revolution began roughly at the turn of the twenty-first century (see Figure 3). According to Klaus Schwab, Founder and Executive Chairman of the World Economic Forum, the Fourth Industrial Revolution grew out of the third; however, it is not a continuation—the speed and the pervasiveness of the technological breakthroughs make this...
AI. AI had reached a milestone in 1997 when IBM’s Deep Blue supercomputer beat world champion Garry Kasparov in chess. John McCarthy introduced the term “artificial intelligence” in 1955—he intended to “study how to make machines use language, form abstractions and concepts, solve the kind of problems now reserved for humans, and improve themselves.” Since then, AI has grown significantly following Moore’s Law. Much of the progress is due to the fast growth in computer processing power, availability of more extensive data sets, and advancement of the fundamental algorithms for machine learning. The boundaries of AI application are almost endless—starting with games and continued improvement of programming languages, vision and image processing, neural networks, expert systems, data integration, robotics, search engines, and much more. For example, IBM, Facebook, Google, and other companies are at the forefront of experimenting with machine learning techniques such as deep learning and predictive learning. AI technologies are predicted to increase the world’s GDP by 14 percent by 2030.

Among Asian countries, China is investing heavily to seize the world’s leading position in AI technology. China intends to use AI for wide-ranging purposes, including improving capabilities of robotics, developing driverless cars, designing digitized factories, making faster chips, predicting crimes, transforming city services, and boosting national security. Although the United States and China are competing for the lead, AI is on the rise in other countries in Southeast Asia, such as Indonesia, Singapore, Thailand, and Viet Nam. For example, Bumrungrad International Hospital in Thailand is the first medical institution outside North America to deploy IBM Watson for oncology, advancing and optimizing cancer care. As predicted by the reputed McKinsey Consulting Firm from the US, AI adoption in Southeast Asian factories could increase profits by as much as US $311 billion per year.

Innovation in artificial intelligence will continue to result in many new industries throughout the twenty-first century. However, a few industries have already been born and are experiencing enormous growth, such as advanced robotics, autonomous vehicles, additive manufacturing/3-D printing, telecommunications and mobile phones, and biotechnology. The United States and Western Europe have made significant progress in all these industries. A brief overview of how these industries are growing in Asia, particularly in China, India, Hong Kong, Japan, South Korea, Singapore, and Taiwan, will be discussed in the following sections.

**Advanced robotics**—As a nation faced with a population that is both shrinking and rapidly aging, Japan is relying on advanced robotics not only to replace future laborers, but also to create future caretakers for its older citizens. The world-famous automobile companies Toyota and Honda have invested heavily in building next-generation robots. Toyota has built female and male models of social robots, Robina and Humanoid, for elder care. Honda’s ASIMO robot is sophisticated enough to interpret human emotions.

Japan, China, and South Korea currently dominate the market in sales for high-value industrial and medical robots. Restaurants that use robot waiters to take orders, serve customers, and clean tables are cropping up in all three countries. China has also invested heavily in industrial automation in order to make its vast manufacturing sector more competitive in global markets.

**Autonomous vehicles**—The concept of an autonomous car, once limited to fiction as in the famous 1980s US TV show Knight Rider, has become a reality—thanks to long-term investment from several companies, notably Google and Tesla. China and Japan are at the forefront of autonomous cars. Japan aspires to make Tokyo a self-driving city in time for the 2020 Olympics.
government is compiling guidelines for self-driving cars and crafting a legal framework as it tests driverless trucks, buses, and taxis on the roads in 2017. Chinese automobile company SAIC Motor received permission to road-test its self-driving cars in California, and China aims to lead the global autonomous car industry by 2030. Among the Asian Tigers, Taiwan, South Korea, and Singapore have made considerable progress in bringing autonomous cars to the market. Multinational company NVIDIA and Taiwan's Industrial Technology Research Institute (ITRI) have partnered in building autonomous vehicles to provide public transportation by 2018. South Korean companies such as Samsung and Hyundai have started making autonomous vehicles as well. South Korea has opened the world's largest factory for testing autonomous cars inside a city environment: K-city, an eighty-eight-acre facility with a budget of US $17 million. Singapore launched the world's first self-driving taxi service in August 2016, with plans to expand to a fully self-driving taxi fleet by this year. Doing so has been an international effort: the French automaker Group PSA partnered with NuTonomy in 2017 to bring more autonomous vehicles to the streets of Singapore. Indian company Novus Drive has been testing the country's first driverless shuttle, and Nissan Motors from Japan has filed numerous self-driving tech patents in India.

Additive manufacturing, or 3-D printing technology—3-D printing was first patented by Charles Hull in the United States in 1986. However, the technology was being developed at the same time in Japan and other European countries. 3-D printing did not grow into its own industry until the start of the twenty-first century. With the development of different types of printers and printing processes, this technology flourished into an industry of its own. Consumer products such as toys and jewelry are already being made using 3-D printers, and 3-D printers themselves have become a consumer product. The tremendous growth of material science technology is another factor for expediting the advancement of the 3-D printing industry. New materials that are lighter, stronger, more adaptive, and more sustainable are being used in 3-D printing parts for robots, automobiles, medical, military, textile, and other industries. The worth of this industry surpassed US $5.1 billion in 2016 and is expected to exceed $21 billion by 2020. China, the world's center of mass manufacturing, has embraced 3-D printing and is about to surpass the US regarding the amount spent on 3-D printers in 2017. Japan and India are also taking advantage of this low-cost production system to enhance their other industries. Taiwan is determined to be one of the leaders in 3-D printing with the help of ITRI. Innovations like 3-D-printed smartphones, musical instruments, and metal 3-D printers are helping Taiwan make significant strides during this technological revolution. Singapore opened its first metal additive manufacturing facility in 2017 to serve Singapore's key industrial sectors, including oil and gas, marine, precision engineering, and construction industries. South Korea invested US $37 million in 2017 to accelerate the development of 3-D printing across the country.

Smartphone Sales by Region

<table>
<thead>
<tr>
<th>Region</th>
<th>Projected Subscribers in Millions</th>
</tr>
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<tbody>
<tr>
<td>Asia Pacific</td>
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<tr>
<td>Europe</td>
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<tr>
<td>Latin America</td>
<td>7,910</td>
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<tr>
<td>Middle East and North Africa</td>
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<tr>
<td>South America</td>
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<td>Sub-Saharan Africa</td>
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<td>North America</td>
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<tr>
<td>Asia Pacific</td>
<td>5,327</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>4,016</td>
</tr>
</tbody>
</table>

Figure 5: Asia will have the largest growth in smartphone sales through 2020 (chart notes subscribers in millions). Source: Business Insider website at https://tinyurl.com/yau5h979.
In India, mobile phones are compared with Swiss Army knives, combining functions such as torchlights, audio recorders, and radio, thus fulfilling diverse societal needs. Such devices have become windows to a world of information, education, livelihood, employment, and lately shopping and e-commerce. In Southeast Asia, mobile apps are being created to diagnose, monitor, and even provide expert assistance for a range of medical illnesses, including malaria and dengue. Mobile phones have also been wirelessly connected to devices like blood pressure monitors, electrocardiographs, and other biometric sensors.34

Social media usage in China is on par with that of the US and Europe. WeChat, a China-based mobile, text, and voice messaging service, gained around 150 million users in just twelve months in 2015. WeChat and QQ are the top mobile apps in China, while WhatsApp and Facebook are most popular in India. While many Asian countries have yet to adopt smartphones and 4G technologies, the next generation of mobile technology—the “5G” system—is in the developing phase. Japan and South Korea are leading in 5G development, followed by the US and China. South Korea is planning to introduce a 5G system partially during the 2018 Winter Olympics, and Japan intends to use it during the 2020 Olympics.35

Biotechnology—Biotechnology as an industry holds tremendous opportunities for growth, particularly in genetic engineering. The US has led research in this field by achieving human genome sequencing in 2003, a feat that took fifteen years and US $2.7 billion. However, today, a decade later, genome sequencing can be done in one or two days at a cost of about US $1,000! China has emerged as a global leader in DNA sequencing, thanks to the Beijing Genomic Institute (BGI).36 Japan has also progressed in genomic research and approved the modification of genes from fertilized human egg cells for basic research in April 2016. Their government has decided to use gene editing to develop treatment for congenital diseases.37 India and other Asian countries are also investing in genomics and in the process of commercializing gene sequencing technology.

Analysis of big data, genetic engineering and other biological breakthroughs, the invention of new materials, and the development of cyber-physical systems are all at the forefront of the Fourth Industrial Revolution, and Asian countries are poised to be significant participants. Supercomputers, drones, smart factories, and nanomaterials are all examples of the achievements of this revolution. Mobile technologies, artificial intelligence, and IoT may make geographical borders irrelevant. However, many governments are trying to enforce boundaries to retain control of technologies. For example, many Google and Facebook apps are blocked in China. New rules and regulations will be needed to navigate the ownerships and uses of these new technologies.

Many emerging economies in Asia became autonomous nations only during the Third Industrial Revolution and were initially far behind the developed world in technology and finance. Nevertheless, these countries have pursued industrialization as a means to reduce poverty and have achieved substantial GDP growth. The direction of the global economy depends largely on Asia, which holds both its biggest share and the greatest share of highly educated young workers. Key ingredients for its success include government policies oriented toward economic and social openness, prioritizing investment in education and innovation, superior technological skills, and—above all—enthusiastic partnerships with citizens in welcoming the technologies of the future. By all indicators, Asia is and will continue to be a dominant force in ushering in the Fourth Industrial Revolution. ■


32. Kline, "Behind the Fall and Rise of China’s Xiaomi:"


34. Ross, 44–75.

