

Snapshots of the global mobility revolution

How will regional variations in China, Europe, Brazil, India, and the United States reshape cars, carmakers, and the automotive “user experience”?

Mobility’s first great inflection point appeared initially in the United States, around 1910, and spread out from there. The second inflection point will follow a different path—taking hold in more global markets, faster—though in various forms and to varied degrees. China’s vast scale will make its role particularly prominent, but other markets will be influential in their own ways. Here are snapshots of the global mobility revolution underway in China, Europe (potentially on the forefront of redefining the nature of premium brands), Brazil and India (whose electrification path may differ from that of other regions), and the United States (a crucible for innovation and competition in the mobility ecosystem).

The China factor in electric and autonomous vehicles

There are twists and turns to be navigated, but the Chinese EV and AV businesses have the potential to be massive.

by Christopher Thomas, Arthur Wang, and Ting Wu

China has been the world's largest automotive market for almost a decade. In 2018, Chinese customers purchased nearly 30 million light vehicles, about 70 percent more than Americans. As the car industry shifts to selling electric and autonomous vehicles (EVs, AVs), China is likely to remain dominant, but in a very different way. McKinsey research suggests that the market solution will be *shared* self-driving cars. By 2040, 55 percent of all passenger-miles could take place in connected electric, autonomous, and shared vehicles—transforming transportation and changing the distribution of profits across the mobility ecosystem.

The urgent case for a mobility revolution

The case for change starts with pollution, which EVs would help address. Three of the ten most polluted cities in the world are in China. Although manufacturing accounts for much of China's pollution, replacing gas- and diesel-powered cars with EVs would lower emissions significantly.

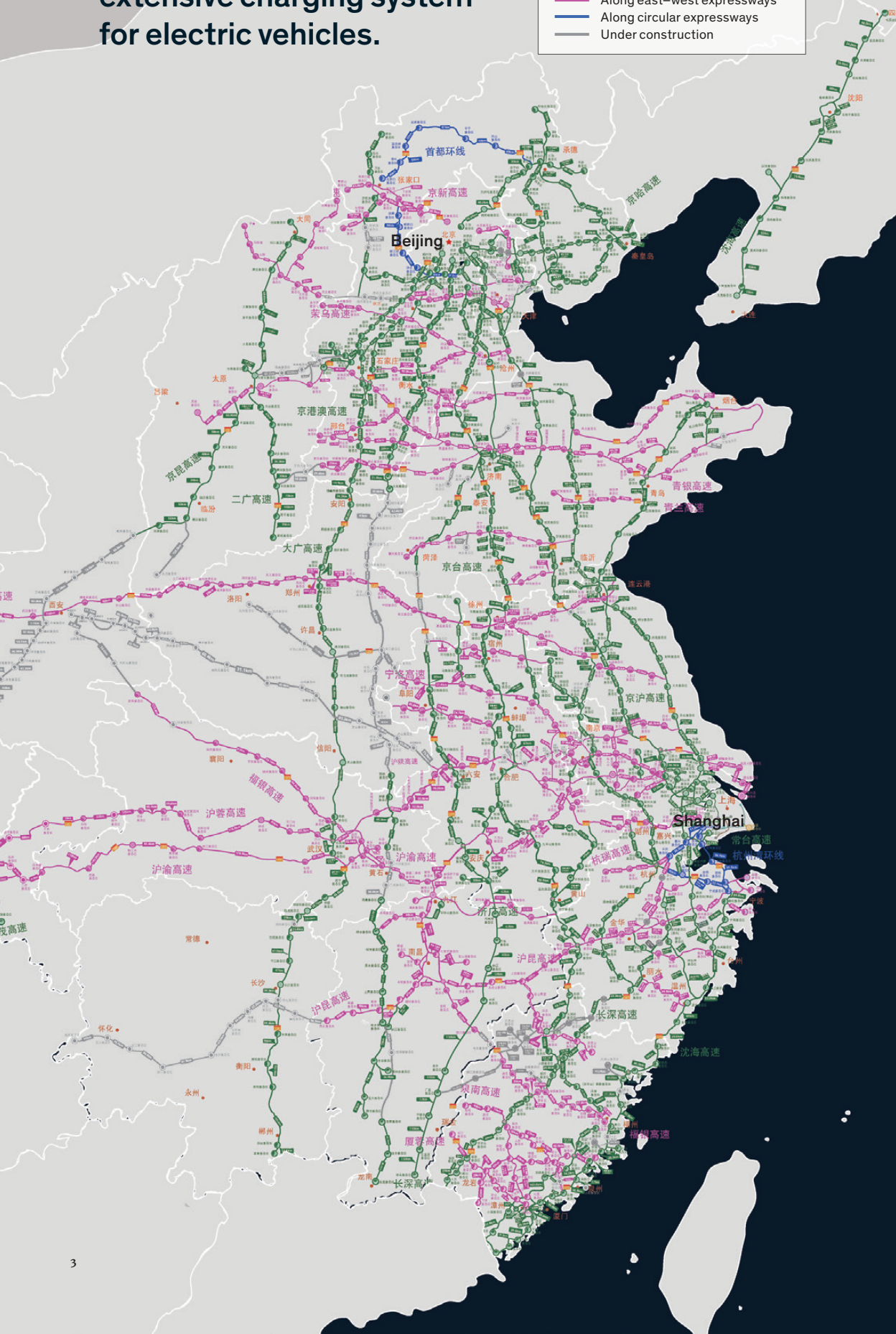
China's government has set a goal that by 2025, one out of every five vehicles sold will be electric. While the United States and Europe wait for the EV market to take off, China has already put an extensive charging system in place. Built mostly along the country's expressways (see map), China has 266,000 stations—43 percent more than Europe and the United States *combined*. Not surprisingly, China is already the leading EV market in the world: In the first half of 2018, 51 percent of the 783,000 electric cars shipped worldwide went to Chinese buyers. And most of those were Chinese brands, such as BYD, SAIC, and Geely.

Still, EVs will do little to solve China's other travel challenge: commuting. A recent study revealed that Beijing workers spend an average of 1.3 hours a day commuting. Hoping to greatly reduce the number of cars on the road, the Chinese government has actively pushed the development of AVs by investing in infrastructure and setting aside multiple autonomous test zones. China's tech giants have established numerous partnerships with foreigners in their drive to be AV leaders. Baidu, for example, has formed the Apollo Group alliance, whose members include such companies as BMW, Bosch, Daimler, Ford, GrabTaxi, Honda, Intel, NVIDIA, TomTom, and Velodyne LiDAR. In total, the country's AV sector has received \$7 billion in funding from venture-capital (VC) groups and foreign companies over the last five years, spurring the creation of many promising start-ups.

China is developing an extensive charging system for electric vehicles.

Charging stations

- Along north-south expressways
- Along east-west expressways
- Along circular expressways
- Under construction



Early signals suggest that Chinese consumers will be receptive to the arrival of AVs. They already like ridesharing and other aspects of mobility-as-a-service (MaaS); some 10 percent of all vehicle sales are to fleets that offer such services. Didi Chuxing, the country's leading ridesharing company, is a global power that successfully fought off Uber's effort to compete in China. Their comfort with MaaS suggests that the Chinese will have little difficulty adapting to autonomous mobility.

A market transformed?

To get a read on when and how the autonomous-vehicle market will develop in China, McKinsey surveyed more than 40 industry experts across the AV ecosystem. We also received input from an external advisory board that included AV experts and executives from automakers, tier-one suppliers, technology companies, and mobility-service providers. Our research suggests that sometime in the late 2020s, the cost of operating a safe (level 4) autonomous robo-taxi should sink below the total cost of a traditional, shared mobility vehicle (exhibit).

Long-haul commercial vehicles and buses will be the earliest adopters of AVs in China, and private commuters will be the early adopter of passenger AVs. Their need is the greatest, and highways are the easiest kind of route for AVs to handle. By the late 2020s, the technology should also be robust enough to handle the twists and turns and congestion of inner cities, allowing AVs to shift from a peripheral technology to a central mode of transportation. If all this transpires, by 2030 13 percent of all vehicle miles could be driven by autonomous vehicles; within a decade, this figure could rise past 50 percent.

Such a market would look quite different from the automotive industry of the last century. Value would shift from end products to core technology components and connectivity-enabled services. Individuals would buy fewer cars and spend more on subscriptions or per-mile fees paid to fleets that give them a ride to wherever they want to go whenever they want to go there. Within the universe of automotive components, AV technology and systems integration could account for more than half of all profits. While passenger-car sales should still generate the most profits, mobility services could well account for a quarter or more of profits in the mobility ecosystem.

Speed bumps

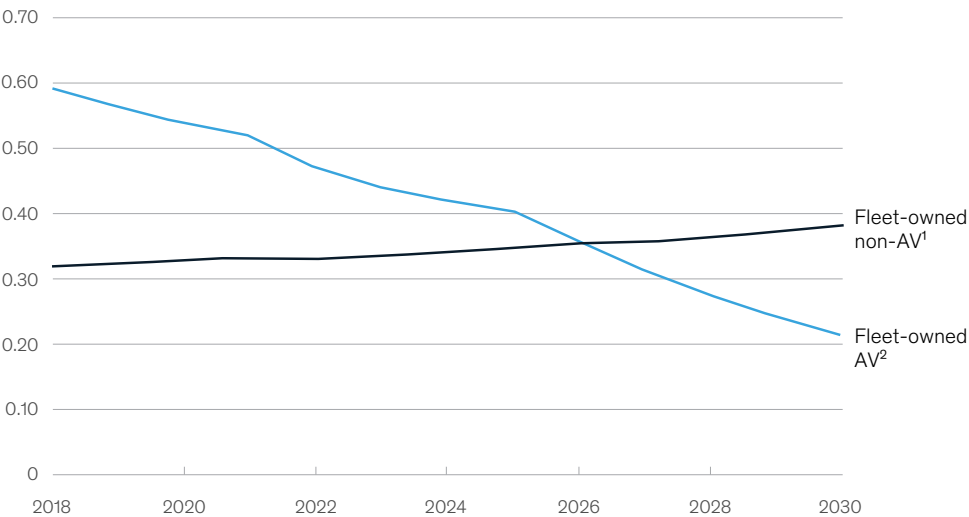
All that said, our scenarios for AV adoption in China do lag behind those in the United States by two or three years, owing to some unique challenges. First, the country's automotive infrastructure is growing every day, with new roads springing up and old ones repurposed. Spread across the world's fourth-biggest land mass, this makes it extremely difficult to consistently maintain the accurate mapping software that's so critical to AVs.

Second, and related, China's road signage is a mess. Traffic lights and road signs in one region may mean something different in another part of the country. In the absence of decent signage, right-of-way issues proliferate. Under the best of circumstances, Chinese drivers, like others around the world, sometimes disregard

Exhibit

Sometime in the mid-to-late 2020s, operating a safe autonomous robo-taxi in China should cost less than owning a traditional driven vehicle.

Mobility-service costs, \$ per km



¹ Assumes fast-adoption scenario; driver is still required for safety in this time frame; AV = autonomous vehicle.

² Assumes use of battery electric vehicle; cost includes depreciation, driver cost, maintenance, insurance, and fuel/electricity fees and excludes fleet-management fee.

road rules; in places where the road rules are nonexistent, drivers become even more unpredictable.

Finally, parts of the technology stack that needs to be built for AVs face so-called negative restrictions (such as governmental limitations on foreign-company involvement). For instance, China’s data-cloud and location-based services will be a critical component of the AV ecosystem, but our research suggests that these opportunities will be reserved for local players (or multinational corporations willing to cede operational control to local partners). Snubbing foreign companies and joint ventures could limit the availability of the best technology for Chinese consumers, disrupt the global AV value chain, and therefore delay the widespread rollout of AVs.

Despite these uncertainties, the economic, environmental, and societal needs addressed by shared electric autonomous transportation argue that its widespread adoption could come sooner rather than later. Within 20 years, Chinese transportation may be completely transformed.

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Europe and the future of premium car brands

As connectivity and interior design grow in importance, European players will help redefine the nature of the premium brand.

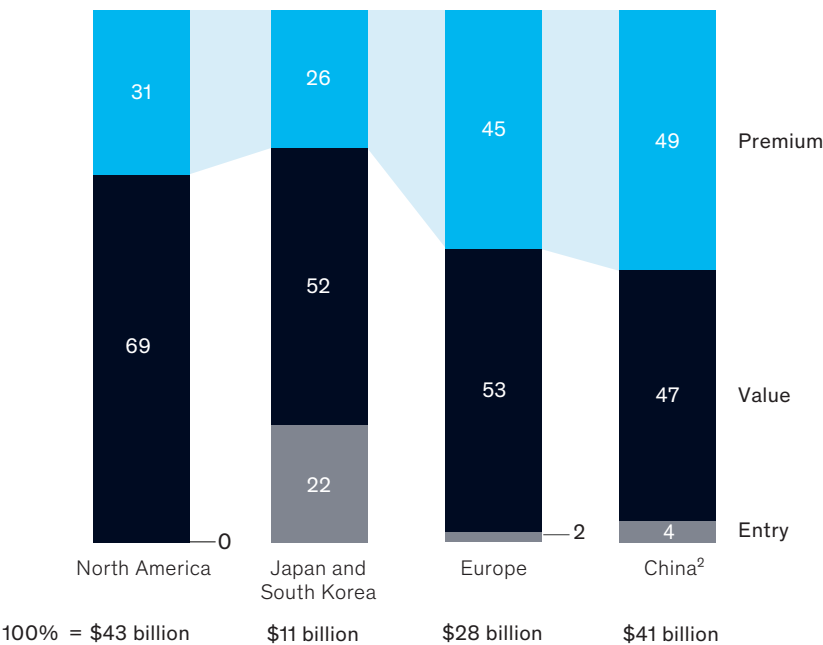
by Jan-Christoph Köstring, Simon Middleton, and Timo Möller

Some of the world's most prominent premium car brands are European. The premium segment also plays a more central role in the economics of European OEMs than of automakers in other regions: premium profits represent nearly half of the total in Europe and China (whose premium sales are themselves dominated by European brands), versus about 30 percent in the United States and about 25 percent in Japan and South Korea (exhibit). To the extent that the emerging mobility environment places ownership and the vehicle user's relationship with the car in flux, it raises questions about the role of high-end brands that are particularly important for European players.

Exhibit

Premium profits represent nearly half of OEM total profits in Europe and China.

Estimated share of 2017 OEM profits¹ by vehicle segment, %



¹ Based on top 21 OEMs.

² Includes China joint ventures, local players, and imports.

Our research suggests that strong brands still are likely to matter. For example, in a recent McKinsey survey, 45 percent of respondents indicated that vehicle brands were “very important” or “important” to their on-demand carsharing experience (versus 18 percent who described the vehicle brand as “not important” or “not at all important”).

However, what matters to premium customers is poised to change. Technical performance, once a hallmark of premium, is becoming commoditized as electric-vehicle technology unlocks levels of performance, such as sub-four-second 0-to-100-kilometer-per-hour acceleration times, that previously were seen only at the highest level of premium vehicles.

Consumer attention is shifting to new attributes, such as battery performance, and to connectivity and design. Connectivity looms large enough that customers appear willing to switch premium brands to get the connected experience they want. Which connectivity features stand out? According to a survey we recently conducted, the most important include vehicle communication with roads, traffic services, and other vehicles—largely for the purposes of navigation—as well as full integration with mobile-phone personal assistants.

Design has always been a consideration for premium customers, but our research suggests that interior design and functionality will grow in importance. Critical differentiators include environmental enhancements such as air purification and comfort features such as massaging seats. Premium customers appear to be looking for multipurpose, ergonomic cabins and for customization of the space to individual needs, such as temperature routing that’s dynamically matched to a driver as they move across vehicles.

In short, the digitization of the mobility experience calls for fresh approaches: personalization, the seamless blending of hardware and software, and the development of a unique design language that extends far beyond the vehicle’s look and feel. Building the capabilities to excel in areas such as these is a priority for every carmaker, and none more than European OEMs that hope, in the years ahead, to redefine the premium brand standard and to stay on its leading edge.

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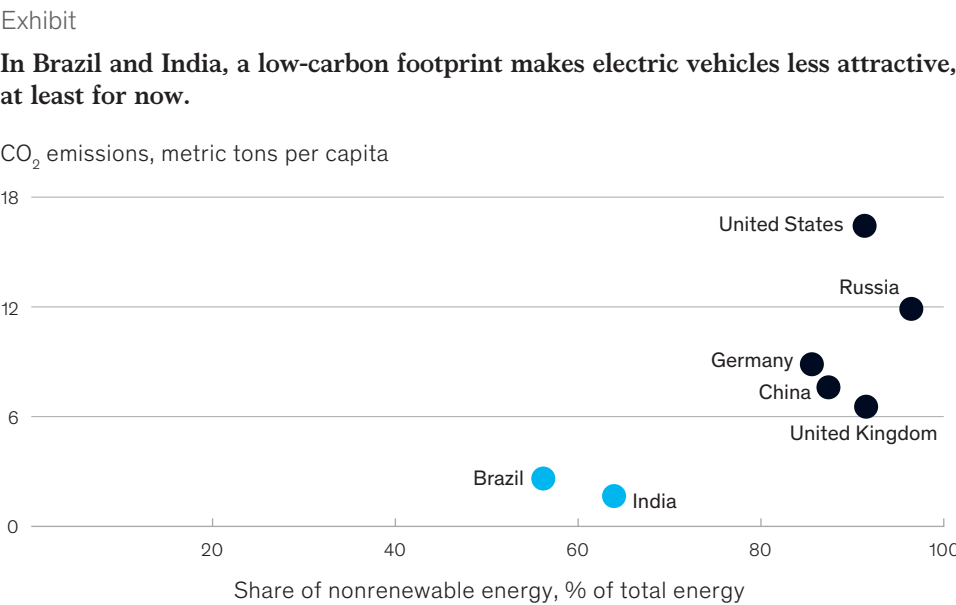
The road less traveled: Brazil and India’s electric-vehicle journey

Electrification faces obstacles in Brazil and India, but it won’t be held down forever.

by Rajat Dhawan, Shivanshu Gupta, and Björn Hagemann

Brazil and India have become meaningful global automotive players: Brazilian car and truck production in 2017 exceeded that of France, while Indian production levels approached those of Germany. As they look to the future, these two emerging markets share an important characteristic that sets them apart from many of the major players. As the exhibit shows, carbon emissions per capita in Brazil and India are lower than in countries such as China, Germany, and the United States, and so is the share of energy derived by each country from nonrenewable sources. That makes electric vehicles relatively less attractive in Brazil and India, at least for the moment.

An alternative to electric vehicles in Brazil is vehicles powered by sugarcane ethanol, which is inexpensive to produce in Brazil and whose life-cycle carbon emissions are similar to those associated with electricity generation. Growth in the number of electric cars will therefore be much more a function of global technology trends than of local necessity. Building up the necessary infrastructure and energy supply (with a focus on renewables) is a critical prerequisite. By 2030, we estimate,



Source: World Bank; McKinsey analysis

electrification could reach 15 to 30 percent of the Brazilian market. The high end would only be possible with dramatic reductions in battery costs.

In India, electrification is in its very early days, with just 2,352 electric vehicles sold in 2017. India is dependent on China for raw materials such as cobalt, and the country is currently at a competitive disadvantage in power electronics and battery manufacturing. Infrastructure is limited, too; for example, there are fewer than 1,000 charging stations in India today.

Nonetheless, there is a growing clamor for electrification as concerns rise in major cities such as Delhi about deteriorating air quality, due in part to particulate-matter emissions from vehicles. More stringent emissions standards go into effect in the 2020–21 timeframe; the government's Energy Efficiency Services Limited recently ordered 20,000 electric vehicles; and orders for electric buses are climbing. In addition to buses, two- and three-wheeled vehicles, luxury passenger vehicles, and light commercial vehicles appear to be the most promising market. By 2030, battery-electric-vehicle penetration in those segments could reach between 25 and 35 percent. Ultimately, India's vast growth potential (it could be the world's third biggest car market by 2030), combined with the pollution and congestion challenges accompanying that growth, will create inescapable incentives for electrification.

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The United States: Crucible of mobility innovation, competition, and ecosystem formation

Mobility's second great inflection point has different economic characteristics than its first one did—creating a host of new opportunities and challenges for US OEMs, start-ups, and tech giants.

by Brian Loh, Abhijit Mahindroo, and Nick Santhanam

The early days of the automobile industry saw a remarkable outpouring of entrepreneurial energy in the United States. Hundreds of automakers and thousands of parts and components suppliers sprang up in the early 20th century, all of them seeking to capitalize on what Alfred Sloan called in *My Years with General Motors* “the great opportunity.”

The approach of mobility’s second great inflection point has brought forth a similar outpouring of innovation and entrepreneurship, particularly in the United States. McKinsey’s Start-up and Investment Landscape Analysis (SILA), a proprietary big data engine, shows that since 2010, more than 1,000 companies pursuing vehicle autonomy, connectivity, electrification, and sharing (ACES) have received more than \$210 billion in external investment. About 40 percent of the companies and investment dollars have taken root in the United States (exhibit). And investment has been accelerating. Average investment levels across the ACES technologies jumped sevenfold in the period 2014 to 2018, compared with 2010 to 2013.

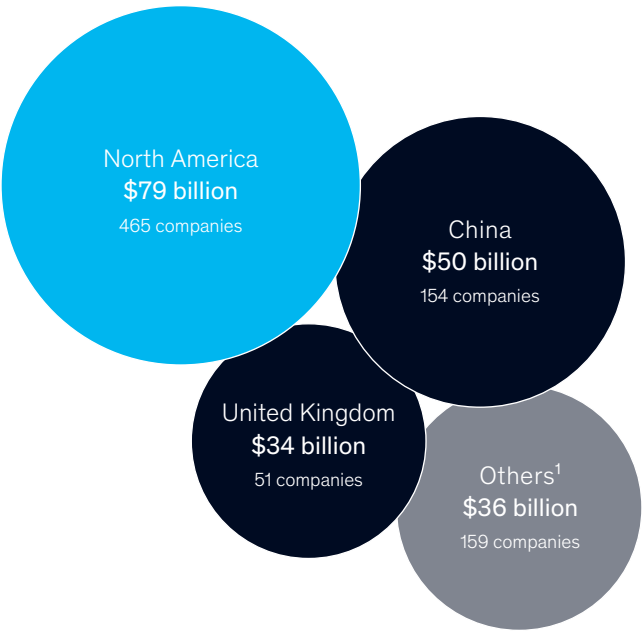
At the time of mobility’s first great inflection, consolidation followed proliferation. The emergence of the Big Three automakers in the United States is the most often-cited evidence, but consolidation also took place at the microlevel. Sloan describes how GM founder William Durant bought up a panoply of companies—some innovators, acquired in an effort “to cover the many possibilities in the engineering future of the automobile,” and others the makers of parts and accessories.¹

¹ Alfred Sloan, *My Years with General Motors*, New York, NY: Crown Business, 1990.

Exhibit

Global investment in future mobility start-ups has been booming, with the United States in the lead.

Total disclosed investment in mobility start-ups since 2010, top 10 countries



¹In descending order by investment: Israel (\$18.5 billion), Singapore (\$6.0 billion), Japan (\$2.8 billion), India (\$2.5 billion), Canada (\$2.2 billion), Hong Kong (\$2.2 billion), and France (\$1.8 billion).
Source: Capital IQ; Pitchbook; McKinsey’s Start-up and Investment Landscape Analysis (SILA)

Today’s OEMs are making massive investments in the future of mobility, including some big acquisitions, such as GM’s 2016 purchase, for about a billion dollars, of Cruise Automation, a self-driving-car unit. Overall, though, their participation in the start-up landgrab has been relatively limited. More than 90 percent of the mobility investments tracked by our SILA analysis were made by players not traditionally seen as automotive companies.

Simultaneously circling the scene is another class of large-scale player—major technology-platform companies such as Alphabet, with its Waymo autonomous-vehicle efforts; Microsoft, with a variety of connectivity and smart-city initiatives; and Amazon, which also has designs on the connected car. Not to be left out of the mobility game are semiconductor players such as Nvidia; Intel, with its \$15 billion acquisition of Mobileye; and Samsung, whose \$8 billion acquisition of the US car infotainment and audio company Harman was noteworthy.

There’s little doubt that the combination of myriad start-ups, big-tech titans, and forward-looking OEMs will make the United States a hotbed of innovation in the years ahead. What’s not clear is who will profit most from the coming inflection point. Economies of scale and scope drove the evolution of industry structure in the United States between 1900 and 1930. While still relevant, these economic fundamentals will be joined in the connected, data-driven future of mobility by key features of the digital economy: network effects, hyperscaling, and the high fixed but near-zero marginal costs of big-tech platforms. Traditional OEMs are already pursuing partnerships with a variety of tech players and could take power positions in this new ecosystem. But disruption is also possible, and it could come quickly. Consider, for example, the speed with which smartphone disruption hit incumbent mobile-phone OEMs, whose global market share fell from more than 80 percent in 2006 to less than a quarter ten years later. Regardless of the outcome, the diversity and competitive intensity of the US mobility ecosystem bodes well for the innovation underpinning mobility’s second great inflection.

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