AUTOMOTIVE INDUSTRY

Here at Last: The Evolution of the Robotaxi

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ARTICLE JANUARY 06, 2026 12 MIN READ

The past decade has witnessed a dramatic evolution in the autonomous vehicle landscape. Initially hailed as revolutionary, robotaxis encountered significant disillusionment after early enthusiasm gave way to challenging realities. Prominent companies exited or pivoted strategies, highlighting the complexities involved.

Now momentum is returning. Recent breakthroughs—ranging from major commercial launches in multiple cities to tangible improvements in reliability, safety, and unit economics—have reignited

optimism. Some experts even foresee millions of robotaxis operating globally by the late 2030s.

The technology has indeed crossed key thresholds. There is now a clear path toward reducing cost per kilometer to as low as 80 cents in the US and the equivalent of 40 cents in China, making robotaxis cost beneficial versus traditional taxi and ride hailing across many regions.

Yet it remains the case that robotaxi adoption will be evolutionary rather than revolutionary. That's not because the technology lacks potential, but because the practical conditions for large-scale deployment develop only gradually. They include:

- **Entering urban markets is costly and takes time.** By our estimate, it takes up to two years and roughly $15 million to $30 million to start commercial operations in a new US city, for example.
- **Scaling up across a metropolitan area also requires time.** At current expansion rates, covering an entire service area will take four to six years. Once technological hurdles are overcome, regulatory limits on annual fleet additions may slow deployment.
- **Consumer adoption is uneven.** Around 60% of Chinese consumers express openness to robotaxis, but only 30% to 35% of US and European consumers say they are willing to use them today.
- **Robotaxis will not compete equally in all cities.** They may capture up to 85% of trips served by ride hailing and traditional taxis in target markets. But for at least a decade, deployment will remain concentrated in major, high-wage urban areas in developed or tech-forward regions.

Taken together, these dynamics will shape both the pace and the ultimate scale of adoption. Viewed holistically, they support a global robotaxi fleet of 700,000 to 3 million vehicles by 2035. That is a realistic outcome that balances the sector's immense promise with the structural constraints that will guide its expansion.

Competing in this emerging market will demand patience and sustained investment, as operators navigate the regulatory, operational, and technological complexities of delivering safe and profitable service at scale. Yet the rewards are equally significant: with millions of robotaxis on the road, the long-term value pool is significant.

Sizing Up the Robotaxi Market

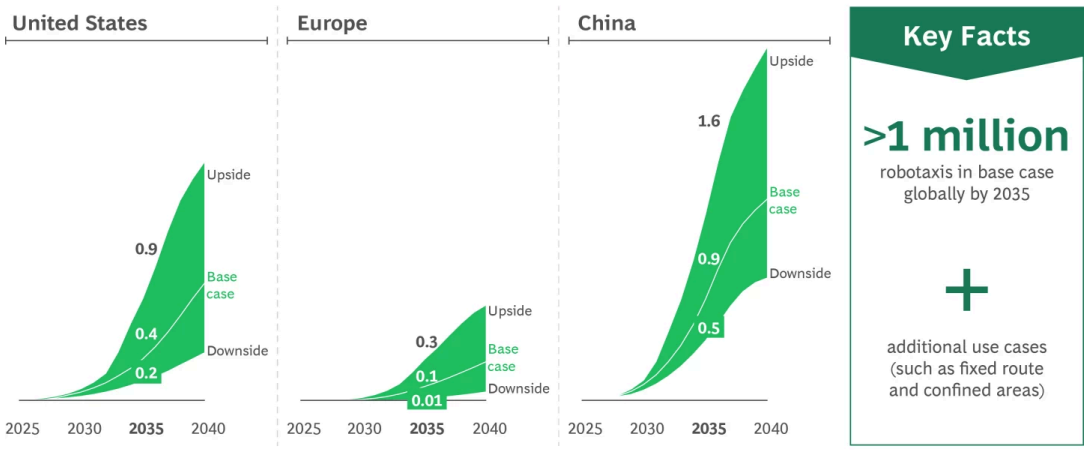
In 2020, publicly accessible robotaxis cruised only one city: Phoenix, Arizona. By the end of 2025, commercial services had reached markets from San Francisco and Los Angeles to Beijing and Wuhan. Fleets remain relatively small but are expanding—and new announcements are coming fast. Waymo has entered US cities like Austin and Atlanta and is preparing to launch services in others in the upcoming months, as well as in London, its first European city. Baidu operates in a number of Chinese cities, including Chongqing and Shenzhen, and has ambitious national and international expansion plans.

Going by recent developments, we expect that the US and China will dominate initial growth, due to supportive regulations, infrastructure investments, and market conditions. In our base scenario, we estimate that the US robotaxi fleet will grow to about 350,000 vehicles by 2035, while China will have about 850,000 vehicles. Robotaxis will be slower to deploy in Europe, where regulatory authority is more fragmented and operating costs are higher. We anticipate roughly 120,000 robotaxis on European streets by 2035. Under a more optimistic scenario in which adoption is high, these numbers can go up to about 3 million vehicles globally. (See Exhibit 1.) Additional potential lies in other use cases, such as fixed-route transport or confined areas.

EXHIBIT 1

More Than 1 Million Robotaxis to Be Deployed by 2035 in Base Case

Projected number of robotaxis, by region (millions)



Source: BCG AV Market Model.
Note: Europe includes the UK.

Five Questions That Will Define the Robotaxi Future

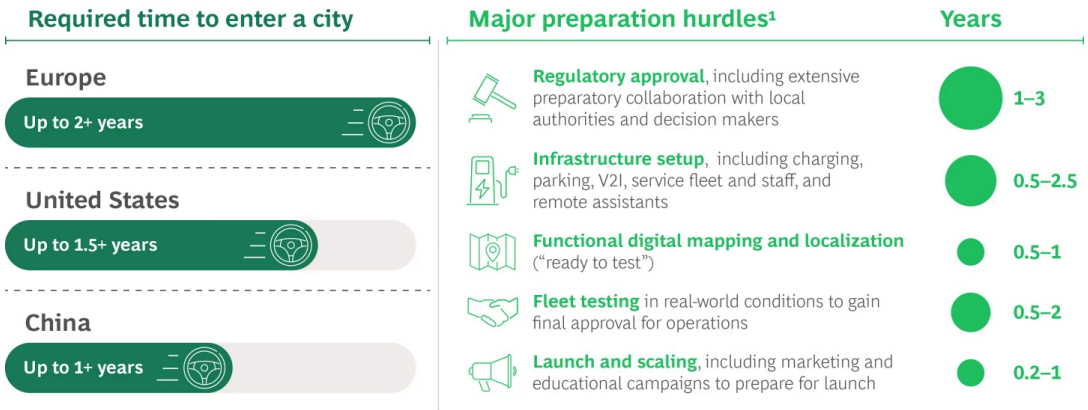
In our view, the ultimate number of deployed robotaxis will depend on multiple factors that can be distilled into five core questions.

What, and how long, will it take for robotaxi operators to enter a new city? Starting commercial robotaxi operations requires time and money. Currently, operators typically must invest around $15 million to $30 million on average to start commercial operations in a new US city. Software, connectivity, and digital mapping and localization efforts account for most of this investment. The cost of entry is expected to drop roughly in half over the next decade as digital tools get more efficient, hardware costs drop, and operations become more streamlined.

What's more, each step of the process of entering a new urban market requires painstaking work. It can take about two years to get the required regulatory approvals for driverless taxi services without a safety driver on board, although approval is typically faster in China than in Europe and North America. Setting up infrastructure, such as charging stations, parking, and service personnel, requires up to two years in the US and 18 months in China. Additional tasks such as digital mapping and localization (which is necessary for testing), fleet testing, and final launch phases can consume six to 18 months. Some of these tasks can be done in parallel, however, and eventually be conducted completely with advanced AI solutions. (See Exhibit 2.)

EXHIBIT 2

Operational Preparation for Robotaxis Is a Major Hurdle in Early Years



Sources: Expert interviews; BCG analysis.
Note: Europe includes the UK.
¹Hurdles can partially be addressed in parallel. Individual timelines are indicative only.

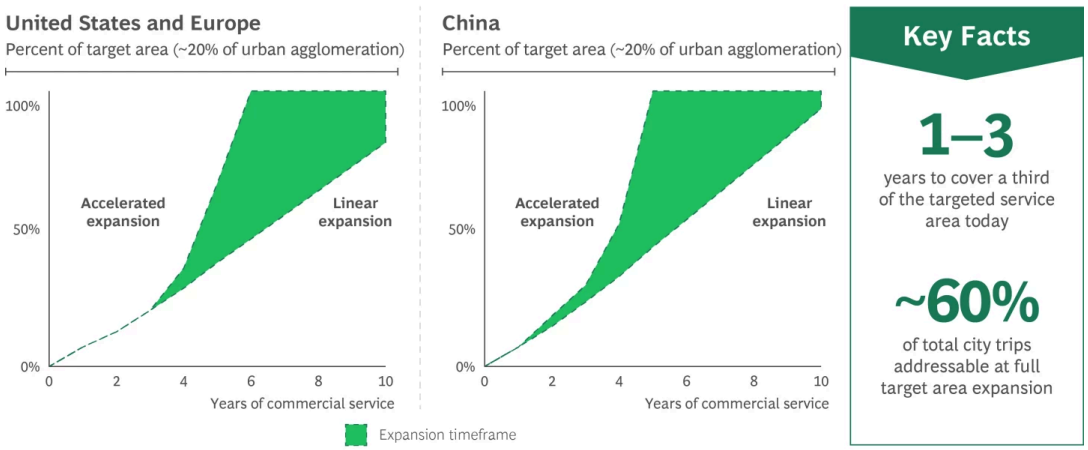
How fast can robotaxi operators scale up? Once robotaxi operations are established in a city, they can't scale up overnight. Operators typically start small in dense, high-demand urban areas. They

then add only 250 to 300 cars a year. Currently, it will take robotaxi services at least three years to cover one-third of a targeted area in a typical US city and six to 10 years to cover 80% of the area. (See Exhibit 3.)

EXHIBIT 3

The Time Needed for Robotaxis to Scale Up in a City Can Be Halved

Time required to cover targeted urban area



Sources: Robotaxi operator publications; BCG analysis.
Note: Europe includes the UK.

The targeted area is expected to represent about 20% of the total area of a typical spread-out urban agglomeration in the US. During these prolonged scaling phases, operators must keep patiently investing to maintain quality of service. Due to technological advancements, we expect this adoption curve to shorten further. However, even if geographical expansion is accelerated, rollout of the fleet is still expected to take time. Even in today's robotaxi epicenters, such as San Francisco and Beijing, robotaxis still only represent less than 1% of the total taxi and ride-hailing fleet after several years of commercial operations. Once technological and initial regulatory hurdles are overcome, regulatory bodies could still limit the number of robotaxis to be deployed per city to roll them out in phases.

Where will robotaxis be deployed? Not every city or mobility mode will be equally suited to robotaxi adoption. They will primarily flourish in economically developed and tech-forward regions, initially in the US and China, and then expand slowly elsewhere in the world. Emerging economies with less developed infrastructure and lower labor costs for drivers will likely lag significantly, perhaps only becoming viable after 2040.

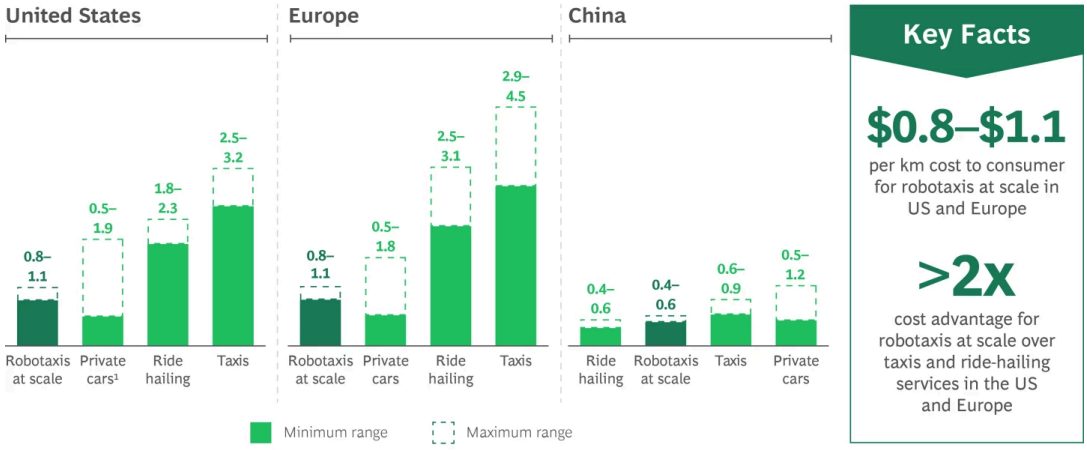
Large metropolitan areas with clear regulatory frameworks, favorable weather, simple street layouts, and high population densities are best suited for robotaxis, which primarily will compete with ride-hailing services and conventional taxis. Smaller cities and cities with more complex infrastructure will likely follow gradually over the next decade.

Today, robotaxis cost more to operate than conventional taxis or ride-hailing services. In some markets, average operating costs exceed $8 per kilometer. For now, most robotaxi operators are keeping customer fares below operating costs to attract customers. When operators achieve full scale, lower operating costs and other factors will enable robotaxi fares to drop to around 80 cents per kilometer, making them a lower-cost option. (See Exhibit 4.) Nevertheless, there will also be space for premium services. For instance, they could offer greater reliability, faster arrival at pickup locations, and higher quality, such as a smoother and quieter driving experience, better cleanliness and strong safety, or ways to customize rides.

EXHIBIT 4

Robotaxis Are Expected to Be Cheaper Than Ride Hailing and Conventional Taxis

Average cost to consumers when robotaxis achieve scale ($ per active kilometer)



Key Facts

$0.8–$1.1
per km cost to consumer for robotaxis at scale in US and Europe

>2x
cost advantage for robotaxis at scale over taxis and ride-hailing services in the US and Europe

Source: BCG AV Market Model.
Note: Single occupancy trips; lower end determined by robotaxi operator cost, higher end as projected average fare to consumers. Europe includes the UK.
¹Parking cost is main driver for wide range of private car trips.

There will be notable regional differences in operating costs, however. Operations will initially be slightly more expensive in Europe compared to the US, due to higher energy and service labor costs and a stricter regulatory environment. Operating costs in China are 30% to 50% lower, due to cheaper technology and lower service labor costs.

When fully scaled, we project that robotaxis will replace between 55% and 85% of the rides in economically developed cities currently served by taxis and ride hailing. Although some consumers will prefer robotaxis over their own cars for selected urban trips that would come at high parking cost, private cars will continue to keep a relevant share—and remain the primary choice for multipurpose trips such as dropping kids at school before going to work. Besides, private cars are expected to stay dominant in cities that do not penalize private car trips via high parking costs, congestion pricing systems, or low-emission zones.

Public transportation will remain largely complementary, rather than competitive, to robotaxi services. However, larger robo vehicles (or robo shuttles) will, in particular, become an important

part of future public transit routes in low-demand areas, where bus driver costs are proportionally higher to the number of passengers transported. They will also allow first- and last-mile connections to public transit hubs and increase accessibility to public transit services in underserved areas.

How ready are consumers to use robotaxis? Establishing robotaxi services is one thing. Convincing people to use them is another. This will also take time and effort. Although around 60% of Chinese consumers currently indicate they are open to robotaxi usage, only around 30% to 35% of US and European consumers express interest, according to a recent BCG survey of more than 9,000 consumers.

For robotaxi services to reach the scale to be profitable, they must expand their customer base beyond early adopters and reach mainstream consumers. We forecast that consumer openness to robotaxis will rise steadily, to about 60% in the US by around 2030 and more than 45% in Europe by 2030 as they become more appealing to users who are interested less in the vehicles' novelty and more in their safety, cost, and reliability.

To support this trend, higher public confidence in the safety of AVs will be important. There is already evidence that robotaxis are less prone to accidents than cars operated by humans. Waymo together with Swiss Re, for instance, has reported that its robotaxis are involved in fewer injuries, accidents reported to police, and air-bag deployments per million miles than human-driven cars. But AV crashes receive wide publicity—and often trigger a regulatory backlash. To convince the skeptics, it will be key for robotaxis to demonstrate and maintain an outstanding, near-perfect safety record.

Can robotaxis be a good business model? Robotaxi firms will only be able to expand if they have a clear path to profitability and the cost of entry is not too high. Some players in the industry have had to invest more than $10 billion up front for R&D before commercial launch. Initially, cost per kilometer will be relatively high, around $5 to $10. Fleet scale and technology improvements will drive these costs down toward 80 cents per kilometer by 2035 in the US, making robotaxis highly competitive compared to traditional taxis and ride-hailing services.

To reach operational break even, we estimate that a robotaxi operator will need to deploy between 15,000 to 20,000 vehicles, likely spread across 10 to 15 cities, to achieve economies of scale. The maturing of technologies will also help. We estimate that robotaxi operating costs can reach the break-even point given projected fares in about seven years. (See Exhibit 5.)

EXHIBIT 5

Robotaxis Can Become Profitable After Approximately Seven Years

Expected operational break-even point for commercial robotaxi services in the US

Source: BCG AV Market Model.
¹Excluding depreciation of development investments.

Beyond passenger fares, operators may generate significant revenue streams from other sources, such as advertising, data services, infrastructure management, and logistics, further enhancing robotaxi business models and returns.

Forces to Watch: Advanced AI Solutions and Regulatory Developments

Given the early stage of the robotaxi market, additional dynamics can influence the scale of adoption. Advanced AI solutions can accelerate robotaxi scaling within cities. And robotaxi operators could choose to expand more rapidly across a wider number of cities.

Adoption could slow, however, if protests by taxi and ride-hailing drivers lead to even stricter regulatory requirements for robotaxis. And a single major incident caused by a robotaxi can lead to years of expansion delays.

Such factors might increase or reduce the number of robotaxis toward the end of the decade, underlining the market's uncertainty. The most likely scenario, therefore, is that development and scaling will be gradual and evolutionary, rather than revolutionary.

The Keys to Speeding Robotaxi Adoption

Whether adoption is gradual or rapid, robotaxis are here to stay. The extent to which they will gain modal share will depend on various factors that can be influenced not only by robotaxi developers themselves, but also consumers, fleet operators, regulators, infrastructure providers, and others.

Building a profitable, full-scale robotaxi operation requires sustained strategic investment, a lot of patience, and close collaboration across the full ecosystem to overcome operational, regulatory, and technical challenges that can delay expansion in any given market.

Key stakeholders can take some of the following concrete actions today to help move the industry toward a faster adoption trajectory:

- **Robotaxi fleet operators** must create comprehensive scale-up plans. Beyond prioritizing and sequencing city rollouts, they should identify all relevant partners in each target market and orchestrate them well in advance of the rollout. Operators should integrate their robotaxis into digital ride-hailing platforms to benefit from network effects and ensure smooth interactions and support. Furthermore, they should educate residents and consumers with trust initiatives, including transparency on vehicle performance, safety, and behavior predictability.
- **Tier 1 providers** of services, such as EV charging depots with smart energy management, efficient and predictive vehicle maintenance, and vehicle cleaning, must be ready to scale up in specific markets targeted by fleet operators. They should start developing their offerings and business cases now to position themselves as go-to service partners.
- **OEMs** should consider developing vehicles that are designed for use as robotaxis. Standard four-seat sedans or hatchbacks, for example, often may not be ideal form factors. OEMs could also move beyond small batch production of robotaxis and prepare to manufacture them at scale. Collaboration will be essential to ensure that user-friendly hardware and software are seamlessly integrated and meet the highest safety and reliability standards. To use their budgets wisely, specific needs and potential rollout speeds of different markets must be understood.
- **Road infrastructure providers** must investigate the assets they manage. Before robotaxi providers scale up, they should identify improvements in road markings, tunnels, bridges, highway interconnections, and multimodal intersections, including sensors, digital interfaces, and data on planned construction. That requires considerable time and investment and extensive collaboration with robotaxi providers, municipal governments, and other stakeholders.

- **Public-sector agencies** at the national, regional, and municipal level can do more to harmonize AV regulations. This is especially important across the EU. Clearly defined rules and standards for liability, insurance, and AV safety will be key. Authorities can also actively promote the most promising commercial robotaxi pilot programs while being careful not to dilute the impact of subsidies by spreading them across too many aspirants. Through public-private cooperation, governments can promote openness in sharing safety statistics and other data to improve transparency and foster public trust.

Navigating the path to widespread robotaxi adoption will require overcoming significant challenges, a tolerance for investing strategically over long time periods, robust collaborative partnerships, and realistic expectation setting. Still, one thing is clear: robotaxis are no longer just a futuristic vision. They are here to stay and will become a sustainable—and eventually profitable—fixture of urban mobility.

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