

EXECUTIVE SUMMARY

The Economics of Robotaxis

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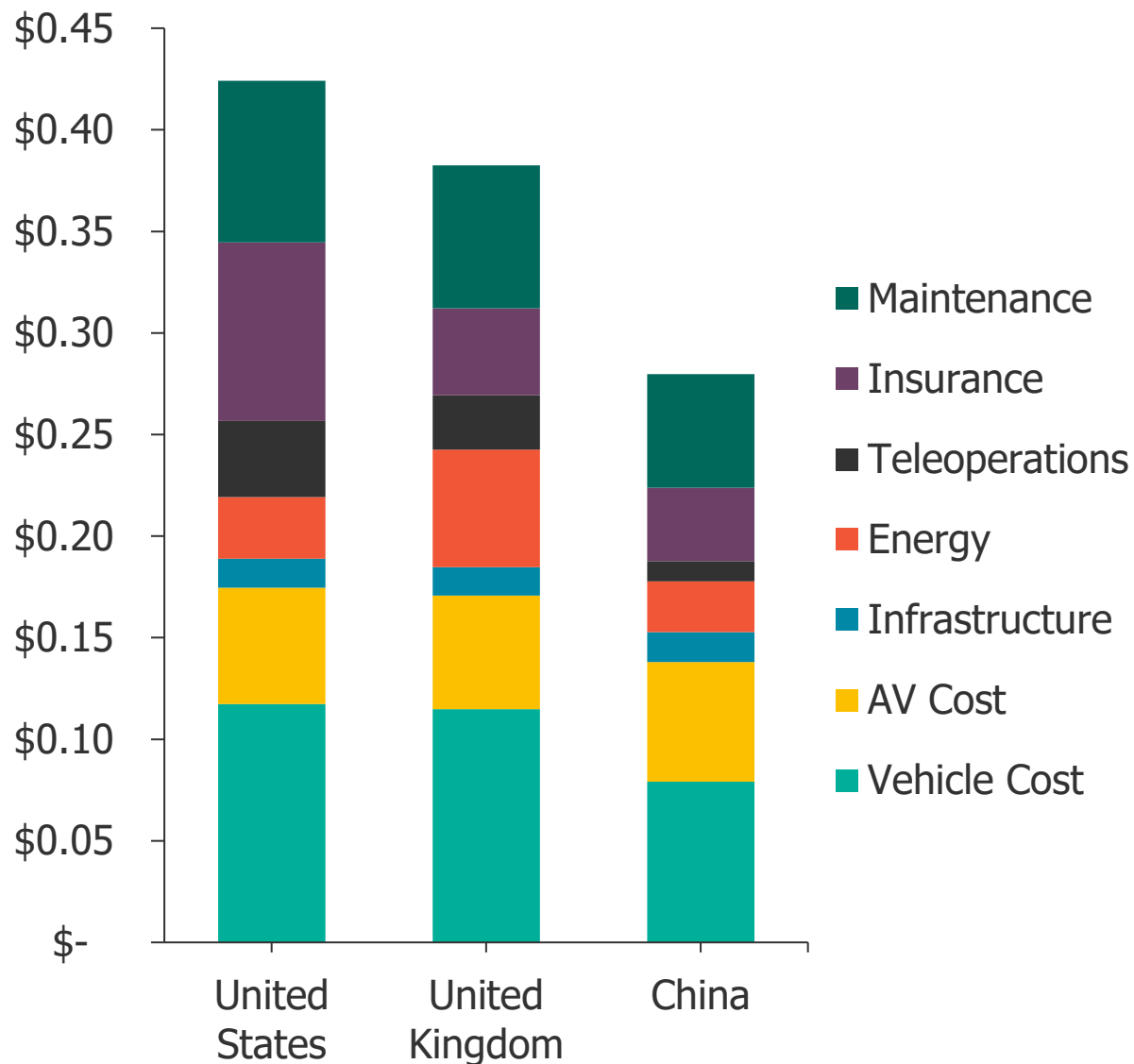
Executive Summary

Robotaxis remain one of the most pursued applications for autonomous vehicle technology today, with many developers proposing an end to – or at least significant reduction in – car ownership. Our analysis of robotaxi economics assessed the costs associated with operating a robotaxi service, finding that maintenance costs and insurance costs are the biggest opportunities to reduce costs.

Ultimately, robotaxi costs will be low enough to displace conventional taxi and ride-hailing services operated by human drivers. However, the expected costs remain higher than most estimates of car ownership costs – especially operating costs for electric vehicles. Poor economics, in tandem with car ownership as a status symbol, make robotaxis unlikely to significantly displace conventional car ownership models.

Robotaxi Costs

USD/mile required to break even



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Robotaxis are the great (potential) disruptor to the automotive industry

Few innovations promise to change the mobility landscape as significantly as autonomous vehicles. Electric vehicles are fundamentally changing what powers our vehicles for the first time in a century, but autonomous vehicles promise to reshape who (or what) is driving them. While seeing self-driving cars on the road today feels new, retrofuturistic visions of the future – such as the magazine cover to the left – usually highlight how drivers will become passengers in the future.

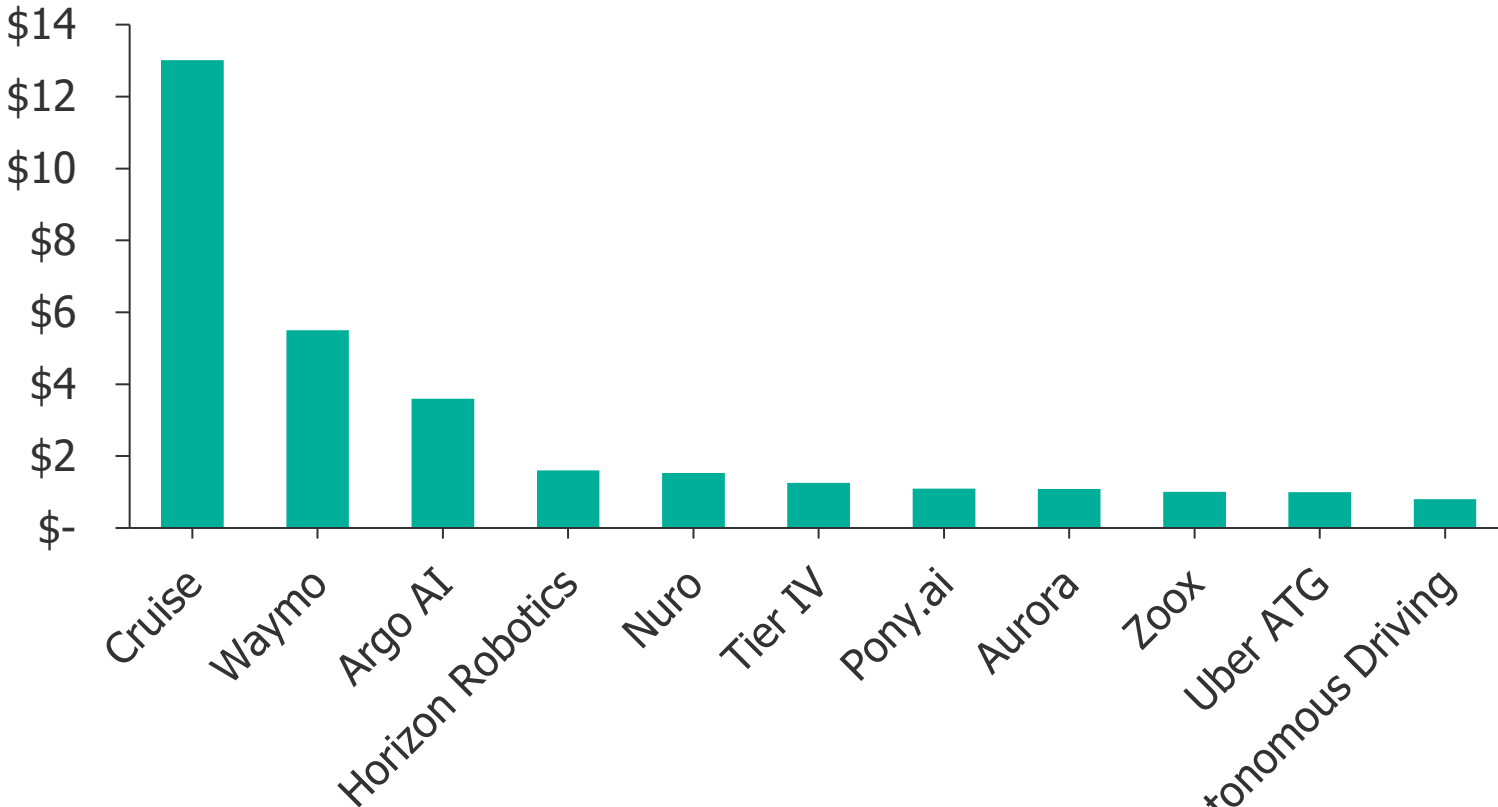
Today's visions of the future still include self-driving cars, but many also envision a future in which we no longer own our cars. Rather, fleets of autonomous taxis – so-called "robotaxis" – provide on-demand mobility services. The potential shift in how vehicles are owned and used is what gives automotive vehicles tremendous disruptive potential. But will this potential be converted into actual disruption?

The largest companies developing autonomous driving are among the most well-funded private companies in the world

Though autonomous vehicles hold immense potential for disruption, they remain an expensive technology to develop. These costs arise from the tens of millions of miles leading companies have navigated while testing their vehicles and the high competition for engineering talent in this area.

With high costs and little revenue, autonomous companies have sought out – and found – tens of billions of dollars worth of investments. The most well-funded companies in the space all have significant backing from major companies – Cruise with Honda and GM, Waymo with Google, and Argo AI with Ford and VW. Not by coincidence, those companies all put a major emphasis on operating robotaxi services.

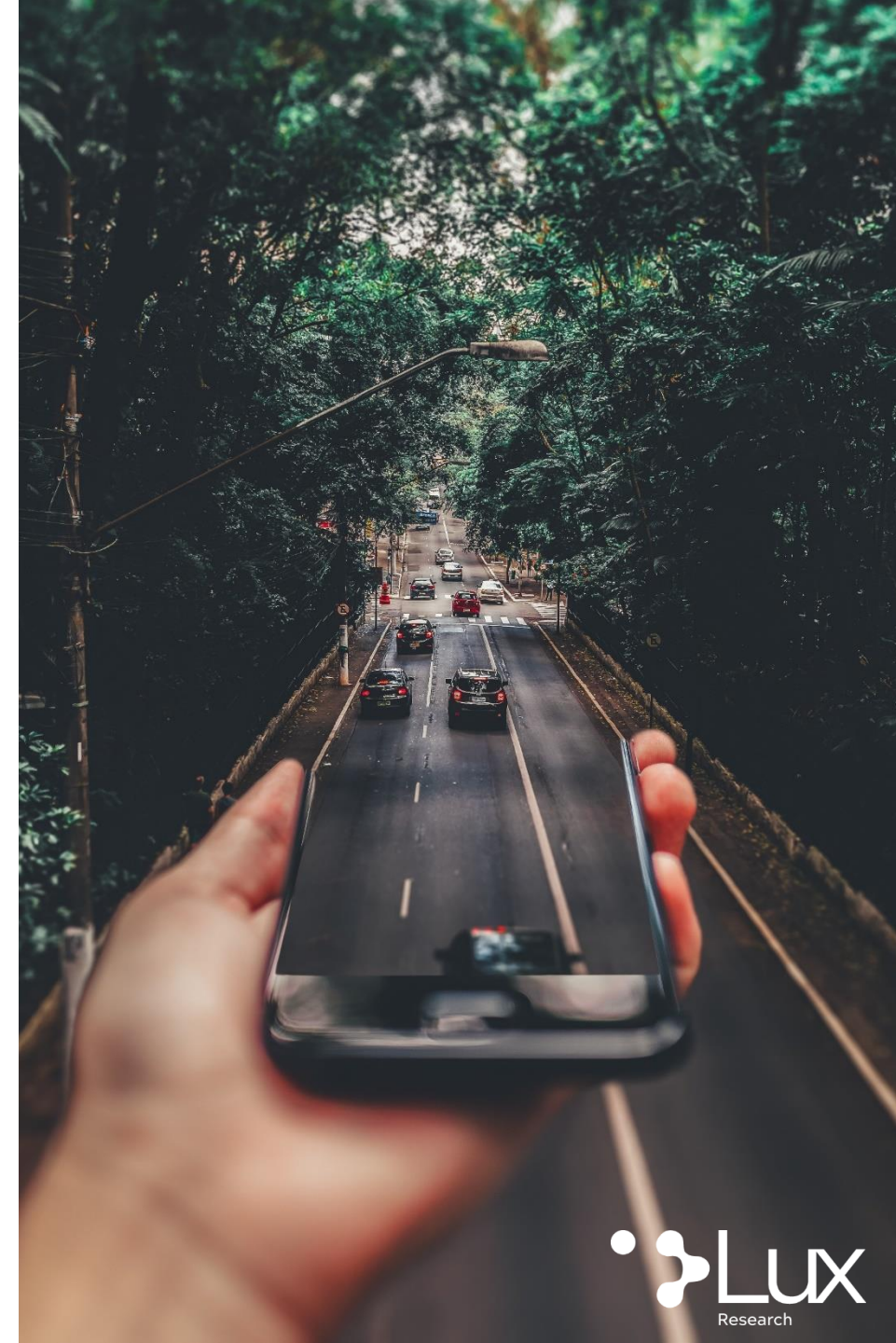
Autonomous vehicle funding
USD (billions)



Robotaxis are currently in the pilot stage, with several operating today

Robotaxi operations require SAE Level 4 autonomous vehicles capable of operating without a backup driver but constrained to specific operating conditions, such as geography or weather conditions. While many early operations feature safety drivers ready to take control of the vehicle at all times, 2020 saw the advent of the first truly driverless robotaxi operations, with reliance on a combination of teleoperators and trailing safety drivers in other vehicles.

It is clear that the required technologies to enable robotaxi services exist today. On the following slides, we highlight key deployments of robotaxis around the globe, focusing on three key projects: Waymo's testing in the U.S., AutoX's testing in China, and Navya's testing in Paris.



But how promising are robotaxis?

Timelines for commercializing autonomous vehicles have continuously slipped, and autonomous driving technology remains unavailable for consumers today. However, as these pilots demonstrate, the technology required to deploy these vehicles exists today, though further testing and refinement is required. We can safely assume geofenced Level 4 autonomous vehicles will be technically mature enough to move beyond pilot testing in the next decade.

However, it is equally – arguably more – important to understand the impact of these vehicles when they are commercialized. Will robotaxis successfully displace car ownership in parts of the world or simply replace taxi services while the same car companies sell the same types of cars to consumers at the same rates? In this report, we analyze the operations of robotaxi networks to quantify the costs per mile of operating them.

Methodology

This analysis focuses on the costs required to operate a robotaxi service, reporting results as a function of the cost/mile in USD across a fleet of vehicles. It does not consider some elements that will factor into the cost of such services, including amortizing R&D, marketing, and customer support costs, due to the challenges of estimating their magnitude. This analysis considers the following costs:

- **Vehicle costs:** Autonomous vehicles are produced today by purchasing conventional vehicles and retrofitting with the required hardware for operating autonomously. Here we estimate capital costs for an electric vehicle and the added cost to retrofit a Level 4 autonomous system.
- **Charging costs:** To keep vehicles charged, we assume fleets will use DC fast chargers, though the costs over a 10-year project life are nearly equal for different levels of fast charging and even battery swapping, as we note in this report. These costs include both the capital costs for installing the infrastructure and the energy costs to power the fleet.
- **Operational costs:** A major difference for robotaxi operators compared to ride-hailing is that operators own the fleet. This analysis includes estimates for these costs, including fleet maintenance, insurance costs, and costs of teleoperation.

The cost per mile calculated in this analysis represents the amount a robotaxi operator would have to charge per mile in order to break even over the life of the project, considering the capital and operating costs listed above. Our analysis includes taxi data, such as total miles driven per year, from three countries – the U.S. using data from Chicago and New York City, the U.K. using data from London, and China using data from Shanghai – to understand how these results vary globally.

BASELINE ROBOTAXI COSTS

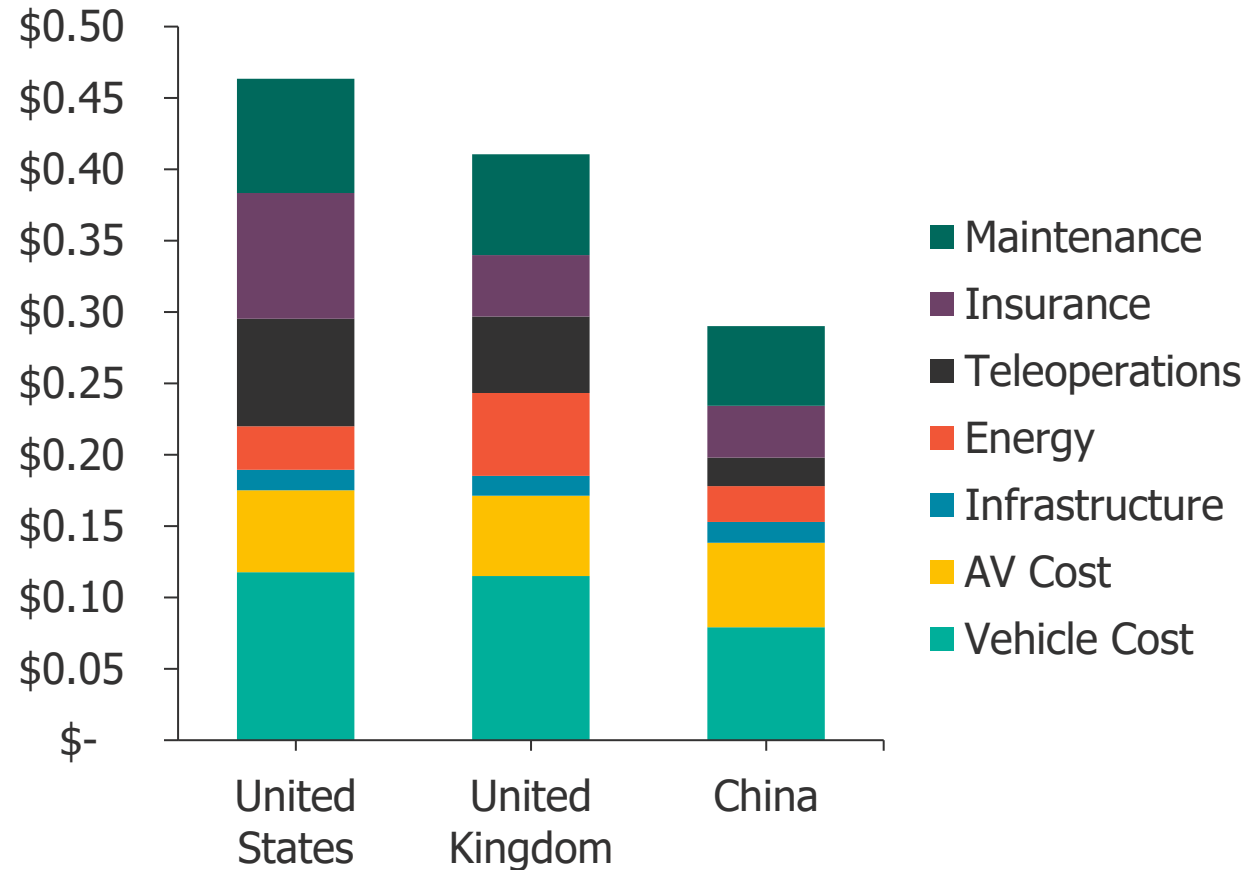
Results

The costs for operating a robotaxi are estimated to be \$0.28/mile in China, \$0.38/mile in the U.K., and \$0.42/mile in the U.S.

In all regions, the costs associated with operating the vehicles (maintenance, insurance, and teleoperations) are roughly equal to those of the vehicles themselves, both being greater than the costs associated with infrastructure and powering the vehicles. The biggest differences between regions arise from differences in vehicle costs, local electricity rates, and insurance costs.

Robotaxi Costs

USD/mile required to break even



Opportunities to reduce costs

Operational costs associated with cleaning, maintenance, and insurance are the largest costs in this analysis but also the most variable from region to region or even city to city. Several avenues to reducing costs exist. Most likely is the elimination of insurance costs; robotaxis are expected to crash less frequently, and larger companies will be able to self-insure their vehicles – though maintenance costs will increase when they do so. Cabin monitoring solutions will enable more efficient cleaning of vehicles, only pulling vehicles for cleaning when necessary.

LUX TAKE

Reducing operating costs is a more important avenue to reducing robotaxi costs today than technology-specific cost reductions like cheaper BEVs and sensors suites. Companies like Waymo and AutoX, which are among the companies with the most testing completed and are already exploring driverless rides, have an advantage in this area.



Image Credit: AutoNews

Is it disruptive?

Though fee structures vary by region and company, most ride-hailing services today charge roughly \$2 per mile in North America and \$1 per mile in China. With operating costs between \$0.46 per mile and \$0.29 per mile, robotaxi operators will likely be able to offer cheaper rides than incumbent ride-hailing services.

Car ownership can be significantly cheaper; in an electric vehicle comparable to those considered in this study, fuel and maintenance costs are less than \$0.10 per mile. However, car ownership isn't all about economics, as the social status associated with car ownership remains high across many regions and generations.

LUX TAKE

Robotaxi operations will be disruptive to incumbent ride-hailing companies due to the significantly more favorable economics, though Uber's pockets were not deep enough to finance the expensive R&D costs. Ultimately, robotaxis will not meaningfully displace car ownership due to higher costs and the social status ascribed to car ownership.



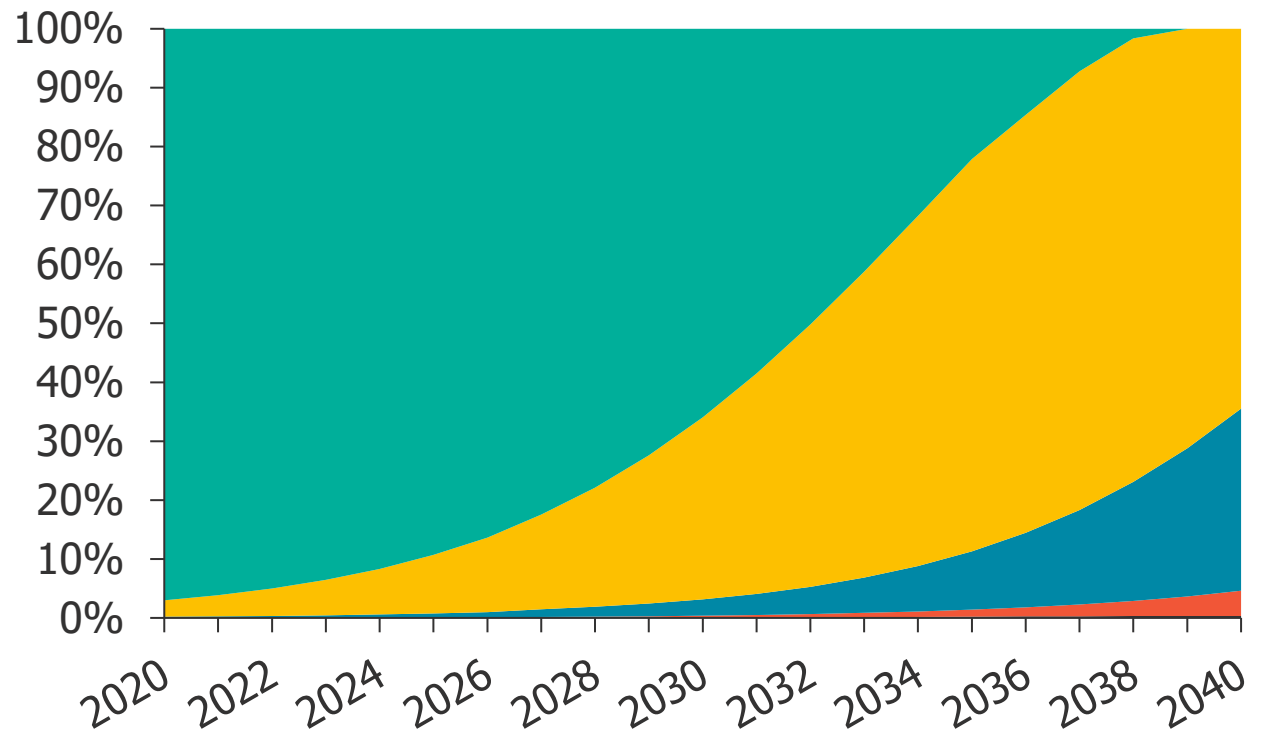
Robotaxis as a development tool

Although Lux does not expect robotaxis to meaningfully displace car ownership, automakers should not necessarily ignore the opportunity completely. Robotaxi operators still need to use vehicles, and no major operators have designed and built their own vehicles. Stellantis has exemplified this strategy, supplying vehicles to several robotaxi operators based on its Chrysler Pacifica minivan.

More importantly, though, automakers and their suppliers can and should consider using robotaxi deployments for development purposes. Our [previous forecasts](#) highlighted that Level 4 autonomous vehicle sales will be higher for personally owned vehicles than for robotaxis. Using robotaxi operations to advance technical capabilities while understanding how consumers interact with them is a promising strategy.

Autonomous vehicle technologies

Market share (%)



■ Level 4 (robotaxi)

■ Level 3

■ Level 0/1

■ Level 4 (personally owned)

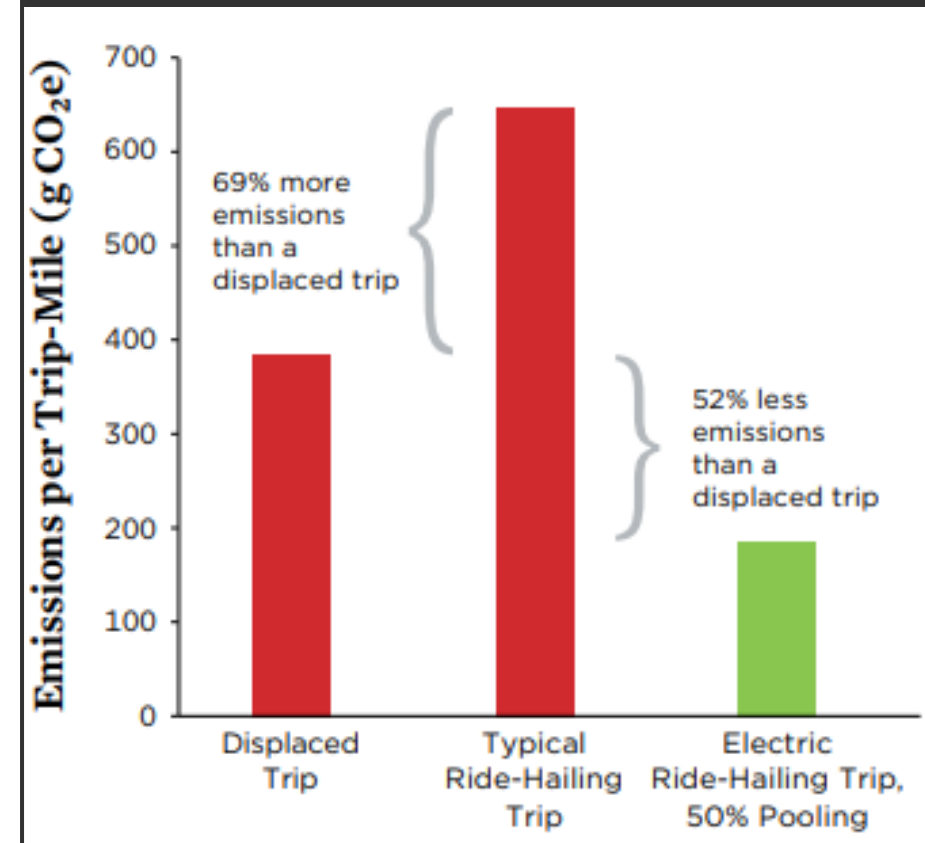
■ Level 2

The role of robotaxis

Governments play an important role in shaping which mobility technologies and services are likely to be commercialized. While some technologies, such as electric vehicles, receive favorable support in the form of subsidies and tax relief, robotaxis will likely be negatively impacted by regulations. As cities grapple with making downtown areas more pedestrian-friendly, reducing emissions, and reducing congestion, more cars are not necessarily the best solution. [The Union of Concerned Scientists](#) found that emissions from ride-hailing increase due to deadhead trips, and [MIT's Insights Into Future Mobility](#) study found that robotaxis may pull ridership away from public transit.

Ultimately, how robotaxis are used will be heavily influenced by how cities regulate them. One promising use case was the Île-de-France Mobilités pilot, which provided first- and last-mile solutions to major points of transit. This solves two challenges: It reduces the negative impact on emissions by reducing the number of trips robotaxis make to city centers, and the shuttle form factor enables higher passenger density to increase revenues. Clients should expect robotaxis to evolve into shuttlelike buses in this use case, as Navya, Zoox, and Cruise have all highlighted.

UCS found shared electric rides can reduce emissions, but conventional ride-hailing models increase emissions in cities.



Source: *Ride-Hailing's Climate Risks*
(Union of Concerned Scientists)



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