BANK OF AMERICA INSTITUTE

BANK OF AMERICA

Transformation

The road ahead: The future of autonomous vehicles

11 September 2025

Key takeaways

- Autonomous vehicle (AV) technology is rapidly advancing, supported by falling hardware costs, AI breakthroughs, and growing deployment of robotaxis and autonomous shuttles. These innovations are enabling more efficient, scalable, and commercially viable autonomous driving systems - bringing the future of mobility closer to reality.
- While accident frequency has declined over the past century, severity is rising, and human error still accounts for 94% of crashes. And while AVs offer the potential for a major leap in road safety, they also raise questions about shifting liability from drivers to manufacturers and software providers.
- As industries and consumers lean in, the AV opportunity spans far beyond passenger cars, with trucks, public transport, and industrial vehicles driving a potential $1.2 trillion market by 2040. Early gains in sectors like mining and agriculture highlight AVs' potential to boost productivity and ease global driver shortages.

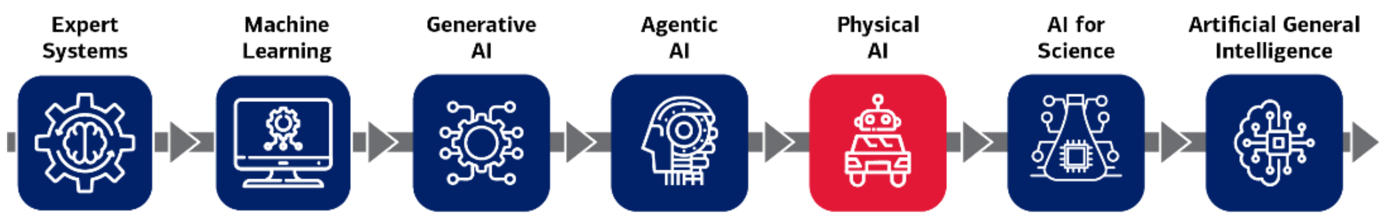
Self-driving cars hit the streets

Supported by the increasing penetration of electric vehicles (EVs) and fast-paced development of AI technologies, "smart driving" is becoming increasingly important in enabling the transformation of traditional mobility (Exhibit 2). Smart driving is powered by the seamless integration of advanced software and hardware systems, allowing vehicles to operate autonomously. And compared with traditional means of transport, it can translate into better safety, lower costs, and improved efficiency.

But how do we go from smart features (think steering or brake support), to being toted around as a passenger without a driver in sight? Well, what was once a futuristic idea is quickly becoming reality with commercial autonomous vehicle (AV) operations gaining traction. Such operations are fully driverless (without a safety driver), they accept passengers, charge a fee, operate on public roads, and are able to operate all day in any weather. Today, there are over 120 robotaxi deployments and shuttles from 32 companies, per BloombergNEF (BNEF). And while many of these are in the testing phase, more than 30 are in various stages of commercialization, with seven being fully commercial.

Exhibit 1: AI capabilities are evolving, with practical applications emerging in physical domains like drones, robotics and autonomous vehicles

AI evolution – Generative AI is advancing from digital to physical domains



Source: BofA Global Research

BANK OF AMERICA INSTITUTE

But not all vehicles are created equally. The Society of Automobile Engineers (SAE) has classified smart driving into five levels:

- **Level 0 / No automation:** The driver is fully in charge of all driving tasks.
- **Level 1 (L1) / Driver assistance:** The vehicle is controlled by the driver, while the vehicle operation may include some driving assistance features (e.g. driving or brake support).
- **Level 2 (L2) / Partial automation:** The vehicle has combined partial autonomous functions like acceleration/brake with steering, but the driver must remain fully engaged with driving tasks and monitor the driving environment at all times.

- **Level 3 (L3) / Conditional automation:** Driver is necessary and must be ready to take control of the vehicle at all times with notice, while driver is not required to monitor the environment.
- **Level 4 (L4) / High automation:** The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.
- **Level 5 (L5) / Full automation:** The vehicle is capable of performing all driving functions under all conditions. The driver may/may not have the option to take control of the vehicle.

Falling tech costs could unlock the future

But why is now the time for AVs? For one, tech costs are falling. Vehicles with sufficient sensor and compute capabilities required for AV operations remain expensive but are getting cheaper with scale. In fact, hardware costs of robotaxis in China have fallen by more than 50% compared to previous AV models. And removing the cost of the driver cuts the cost per mile by 52%, per BofA Global Research, which can unlock more addressable markets.

BofA Global Research also notes that a fleet of one million AVs could unlock up to $50 billion revenue-generating miles, which suggests that achieving driver-out commercial operations would create significant economic potential, even with a relatively small fleet (compared to the 1.4 billion cars on the road globally).

What else impacts commercialization?

Beyond cost-effective technology, other factors are critical to successful AV commercialization including safety, utilization and fleet management. The variable demand in ride hailing services could leave 95% of the fleet lying idle in off-peak trough periods, such as overnight. This would severely hamper utilization and potentially lead to higher empty miles, as AVs are reallocated between paid rides.

Furthermore, the past decade has seen the rise of "asset-light" mobility service aggregators, driven by drivers willing to incur most of the fleet/asset costs, e.g. vehicle depreciation and maintenance. These aggregators have provided a growing user base of riders and trips in return for a cut of the fare. However, AV business models where the fleet is owned/operated could reverse this, requiring large balance sheets to finance.

But are we ready to give up the wheel? The public remains hesitant, with just 13% of US adults prepared to trust AV tech and 53% citing safety concerns as the main obstacle to more widespread AV adoption.[1] Yet, interest and discussion of AVs on social media has surged of late, owing to more commercial launches. Ultimately, however, more testing, marketing, and commercial deployment of AVs will be required to shift the narrative and increase AV adoption.

The ChatGPT moment for mobility

From AV1.0 (rules-based approach) to AV2.0 (end-to-end approach)

Generative AI is accelerating the revolution in transportation, bringing AVs closer to reality (Exhibit 2). As such, BofA Global Research believes that we are moving from AV1.0 to AV2.0: from a rules-based approach, where an AV has multiple neural networks, each performing different tasks individually, to an end-to-end approach, where generative AI can combine AV tech into a single end-to-end AI-based stack. With this new era of AV2.0, a single AI model can translate the raw sensor data into how the AV should drive.

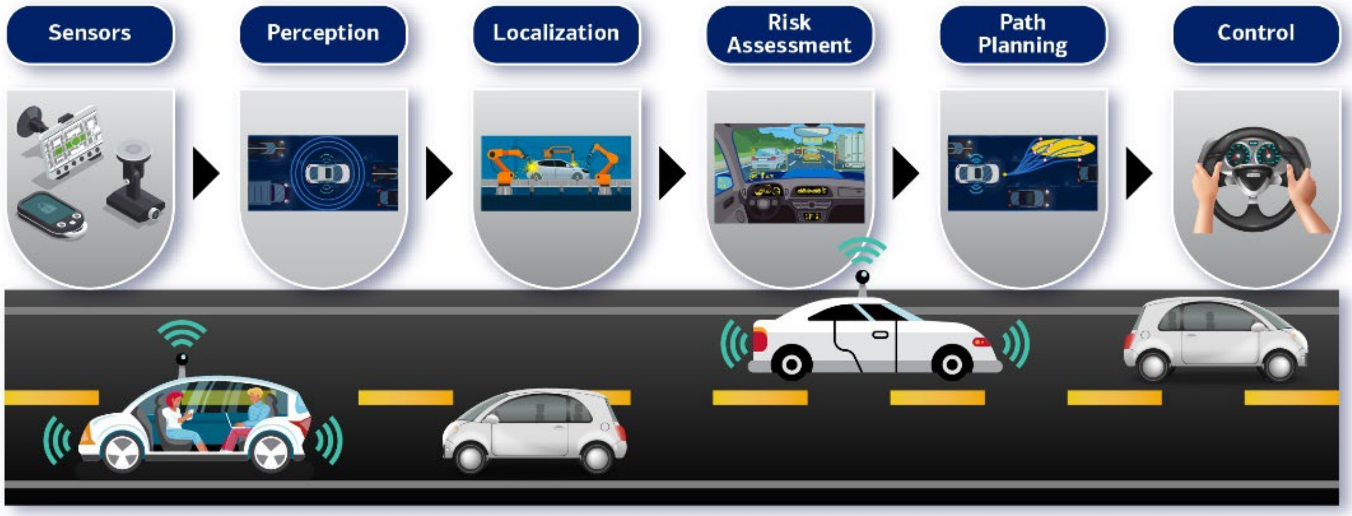
Generative AI and simulation tools are enabling AV2.0

Since ChatGPT's release in November 2022, we have seen numerous generative AI developments. Today, generative AI models can be used for simulation to train AVs. The simulation process can represent and predict driving scenarios and dynamic information (such as motion, force, and distance). When combined with "ground truth data" (such as speed, location, and object detection) and sensor data from vehicles, these advanced simulators can represent any physical environment the vehicle will operate in, to replicate the behaviors of AVs on the road.

[1] AAA, *Autonomous Vehicle Survey*. February 2025.

Exhibit 2: Technology is required at all stages of self-driving vehicles, combining sensor information with localization and mapping information to plan a safe path forward before initiating movement of the vehicle

Stages in autonomous driving: converting sensor information to vehicle control



Source: BofA Global Research

BANK OF AMERICA INSTITUTE

What do smart cars and AVs need? Compute, energy and sensors

The smart car supply chain mainly consists of smart driving systems, smart cabin systems, and other smart components (e.g., smart auto lights). The smart driving functions rely on an integrated system of sensing, processing, and control (Exhibit 3). Sensors collect environmental data, processing units analyze this data to make decisions, and control systems actuate the vehicle based on those decisions. This process enables vehicles to perceive their surroundings, plan paths, and execute movements. Meanwhile, smart cabin systems might include a cockpit domain controller, in-vehicle infotainment/information display system, a heads-up display (HUD), and a streaming media rearview mirror.

How do cars "see"? Sensors paired with data and compute power

Sensor tech, e.g. radar, cameras and lasers (such as LiDAR), collect data on the AV's environment, which is then processed to inform the vehicle's decision-making. The process involves: 1) Data collection, generation and labelling occurring in data centers; 2) Simulation tools that replicate the AV's physical environment; and 3) In-vehicle compute to run trained AI models in real time and safely.

The AV sensor market was already worth upwards of $75 billion in 2024, most of which is currently used for advanced driver-assistance systems (ADAS) including driver alerts, speed/lane changes and automated parking. Increasing the sensor count combined with sufficient data, compute and AI capabilities is enabling higher levels of automation to be achieved.

AV sensors cost 9x more than ADAS but AI breakthroughs could reduce this

Initial AV test fleet deployments have required a high volume of sensors. The global average sensor content cost for a Level 4 vehicle (a self-driving vehicle without human intervention in defined areas) is 9x that of an L2+ system (partial automation driver assistance). However, AI breakthroughs could reduce this over time.

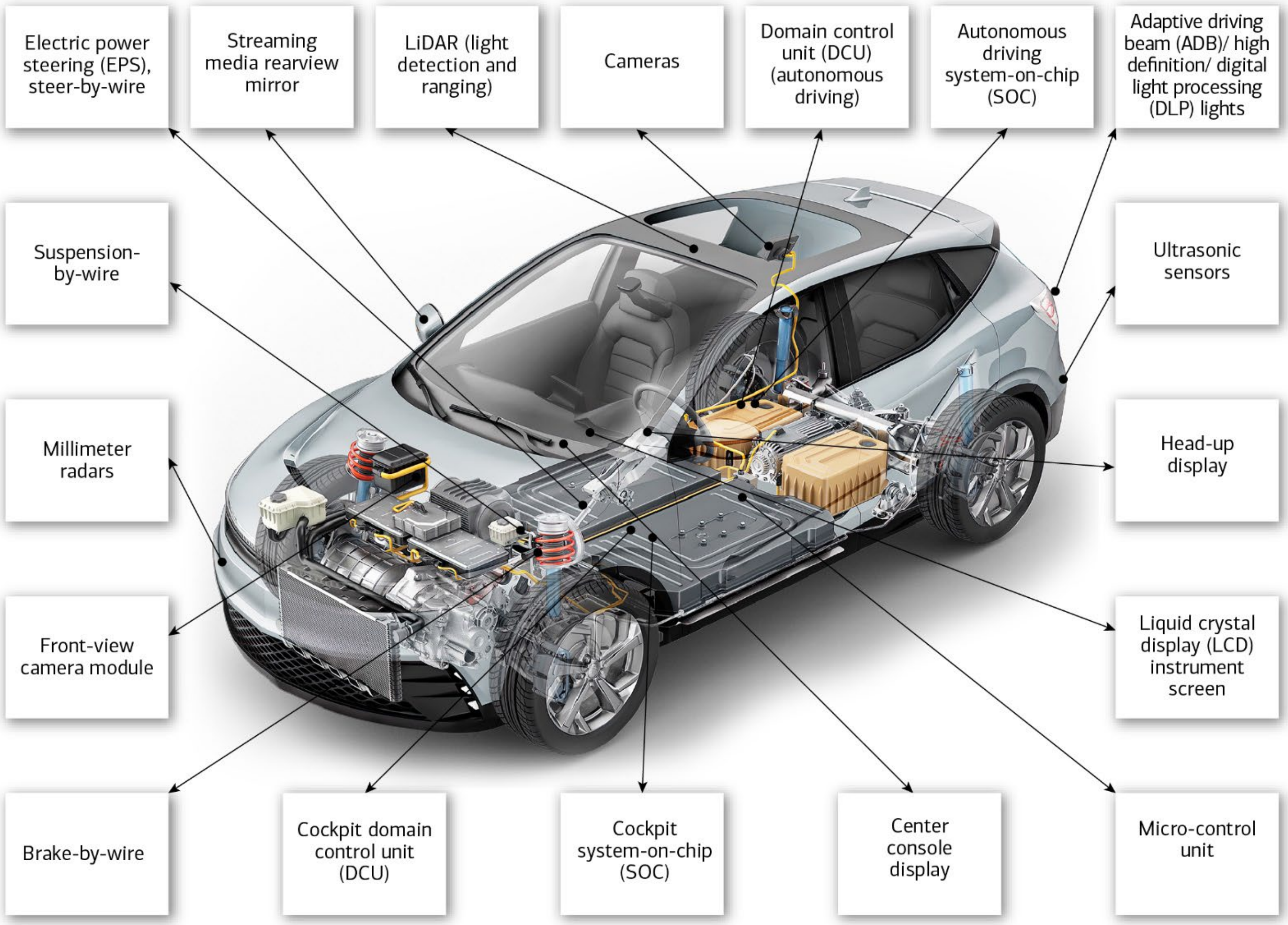
The end-to-end AI approach to autonomy (AV2.0) can operate with the equipment most premium vehicle manufacturers are building into vehicles already, thus requiring minimal or no additional hardware on the vehicles to enable AV operations. If successful, such deployments could limit the sensor requirements to achieve automated driving, albeit at the expense of additional data, training and compute requirements.

Supercomputers on wheels

Recent advancements in compute will likely improve auto-driving systems significantly. For example, AVs used to rely on data in image format to "see," but the new generative AI chips provide enough compute for the AV systems to learn directly from data in video format, which will be much more efficient. AI and GPUs (graphics processing units) will enable AV systems to become familiar with new environments more efficiently, making it possible for AV companies to accelerate commercial operation. As a result, AI model developers are specifically targeting AVs as a key commercial application for the physical embodiment of their models.

Exhibit 3: Smart driving functions rely on an integrated system of sensing, processing and control

Smart car technologies



Source: BofA Global Research

BANK OF AMERICA INSTITUTE

AI Infrastructure growth: 10x more GPUs and 17x data storage for AV2.0

Just one autonomous test vehicle running for six hours generates 32TB (terabytes) of data, enough to fill the storage on 256 iPhones. In the end-to-end AI model approach to autonomous driving (AV2.0), the size of the AI model required to train/run these test vehicles would rise 13-fold in just three years, with the required data storage growing 17-fold, implying that even a small test fleet of AVs (50 vehicles) could require upwards of 100 petabytes (or 100,000TB) of data storage after three years.

As a result, the processing power in data centers needs to grow equivalently to efficiently train and run the models. This could rise 10x from a current estimated 8,000 GPUs for a L2 ADAS system to 80,000 GPUs for an end-to-end AI model for autonomous driving, per Nvidia.

Loss trends, liability and insurance…

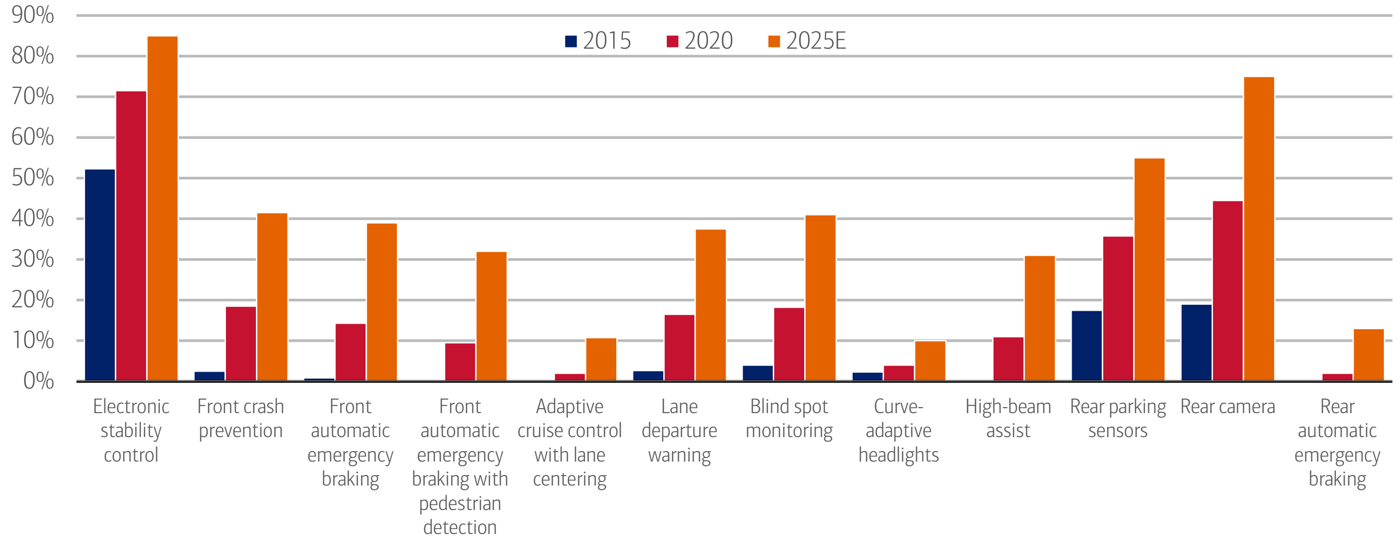
The explosion/outgrowth of ADAS/AV features on automobiles, has deep implications for road safety and liability. BofA Global Research notes two main considerations to keep in mind as autonomous vehicles grow more prevalent:

1. Safer cars:

For over a century, auto accident frequency has steadily declined. However, in the past two to three decades, despite a wave of safety innovations, the rate of improvement has slowed noticeably. At the same time, the severity of auto accidents appears to be rising – outpacing the benefits gained from recent technological advances. Further, the frequency of high-severity accidents does not appear to be improving with the proportion of “total wrecks” rising precipitously from where they were a decade ago.

Road traffic accidents are the cause of 3,000 deaths a day globally and up to 50 million injuries and disabilities per year, costing countries 3% of their GDP on average.[2] However, many road safety improvements over time have been achieved through technological advances and are now commonplace across all modern vehicles (e.g. seatbelts, airbags) (Exhibit 4). But with 94% of road traffic accidents still attributable to human error, people are going to start to more heavily leverage the related self-driving technologies in the cars—like front accident avoidance and adaptive cruise control. And while it's not going to happen overnight, it is hoped that AVs can enable the next revolution in road safety improvements.

Exhibit 4: Several automotive safety features have reached critical mass in terms of their prevalence within the registered vehicle population
Percentage of registered vehicles with various collision avoidance systems in 2015, 2020 and 2025E



Source: BofA Global Research; Highway Loss Data Institute (www.iihs.org)

BANK OF AMERICA INSTITUTE

2. Changing onus of liability:

At a prominent investor conference some years ago, where top minds gathered to share bold ideas, most pitches leaned toward the usual suspects: cutting-edge tech and breakthrough medical innovations. But one stood out. It focused on a traditionally overlooked sector—insurance—and made a provocative claim: 'Soon, cars will drive themselves. And when they do, auto accidents will vanish. So too will the need for personal auto insurance.' Like rotary phones and VHS tapes, it suggested, personal auto insurance could become a relic of the past—faster than anyone expects.

When an accident occurs, if the question is whether the software works or whether the car functions right, you aren't going to buy the insurance anymore. It's going to be the software provider's or the automobile manufacturer's insurance. Could liability shift away from personal auto carriers toward commercial carriers as car makers, parts manufacturers and software engineers become increasingly responsible for accidents that are "the car's fault" and not "the driver's"?

With that said, other motorists can crash into a self-driving vehicle as easily as into your current ride. There will still be floods, hailstorms and falling trees. There were over a million vehicle thefts in both 2022 and 2023 (down to 851,000 in 2024). The insurance companies are not just providers of protection. Regardless of who is liable, automotive insurance provides the logistics around vehicle repair and replacement. But keep in mind that the technologies that are paving the way for vehicle autonomy are also causing the cost of auto repair to rise due to higher costs of replacement parts and extended turnaround times. Regardless, the need to insure one's vehicle would continue to exist in a world of vehicle autonomy – it just might look a bit different.

A $1.2 trillion opportunity by 2040; it's not just about the car

While much of the AV attention thus far relates to the car, other types of on- and off-road autonomous vehicles are beginning to commercialize, indicating that anything that moves could be set for automation. While cars represent the largest market at $700 billion by 2040, the addressable market more than doubles to $1.2 trillion when including trucks, public transport, industrial, and off-road applications (Exhibit 5). Autonomous mining and agricultural vehicles are available already, some noting 30% productivity improvements and 50% labor cost savings.

Solving the global driver shortage

There is a 3.6 million truck driver shortage globally, projected to double by 2028 with the biggest structural concern being the widening age gap. Per the IRU (International Road Transport Union), the average truck driver in Europe is 47 and the average bus

[2] World Health Organization, *Road traffic injuries.* December 2023.

driver is 50 (vs. the average active worker's age of 43). And according to Statista, Japanese taxi drivers were on average 59.7 years old in 2023, the oldest workforce in the road transport industry. Taxi driver numbers in London reduced more than a third over 2014-24, as the average driver age gradually increases with a lack of younger drivers to replace retiring ones. If this were to continue at the current rate, there'd be no London taxis as soon as 2045. It's with this in mind that AVs are increasingly seen by both developers and policymakers as offering potential to fill some of this gap and to complement human driving.

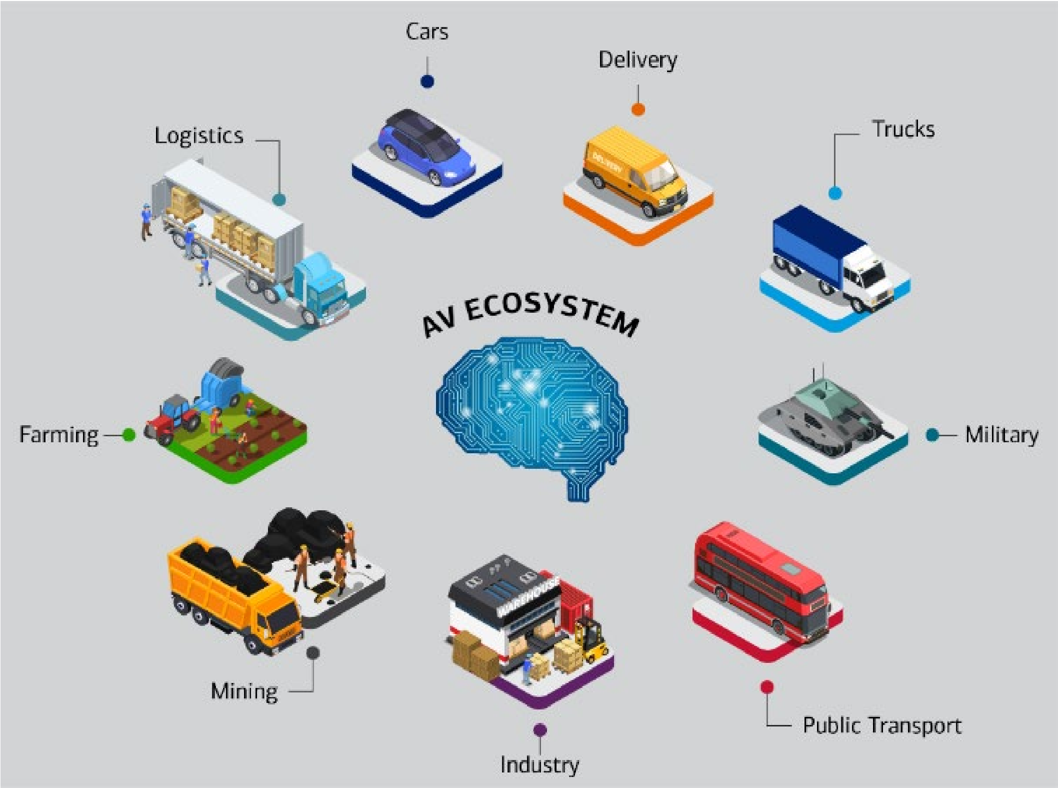
Robotrucks are coming, with seven nearing commercialization

Autonomous trucks are becoming a reality, aiming to disrupt a $4 trillion global freight market by enabling cheaper services and mitigating several structural challenges, particularly driver shortages. There are 90 operational pilots, two-thirds of which are in long-haul trucking. Seven of these are nearing full commercialization as the technology becomes increasingly viable and regulatory environment amenable to AVs.

Furthermore, partnerships between truck manufacturers and AV developers are forming, with the aim to commercialize services with factory-integrated AV tech, made available to fleet partners via pay per mile (driver-as-a-service) or full-service leasing (capacity-as-a-service) business models. The majority currently target 2027 for ramping the commercial offering.

Exhibit 5: The AV ecosystem can potentially expand beyond cars and trucks and into mining, farming and other industry uses

On-road and off-road opportunities across the AV ecosystem



Source: BofA Global Research

BANK OF AMERICA INSTITUTE

AV investments heating up

$9 billion in investment to AV companies over 2023-24

BofA Global Research notes that investments in AV companies tripled from 2023-24 to $9 billion, per PitchBook data, owing to a combination of AI breakthroughs, early-stage AV launches, and consolidation of companies with AV technology reportedly nearing commercial readiness. And according to McKinsey, over $200 billion was invested in around 600 AV companies from 2010 to 2024, with almost $1 trillion invested in total across related trends of connected, electric and shared mobility.

Autonomy is key in the race for global tech supremacy

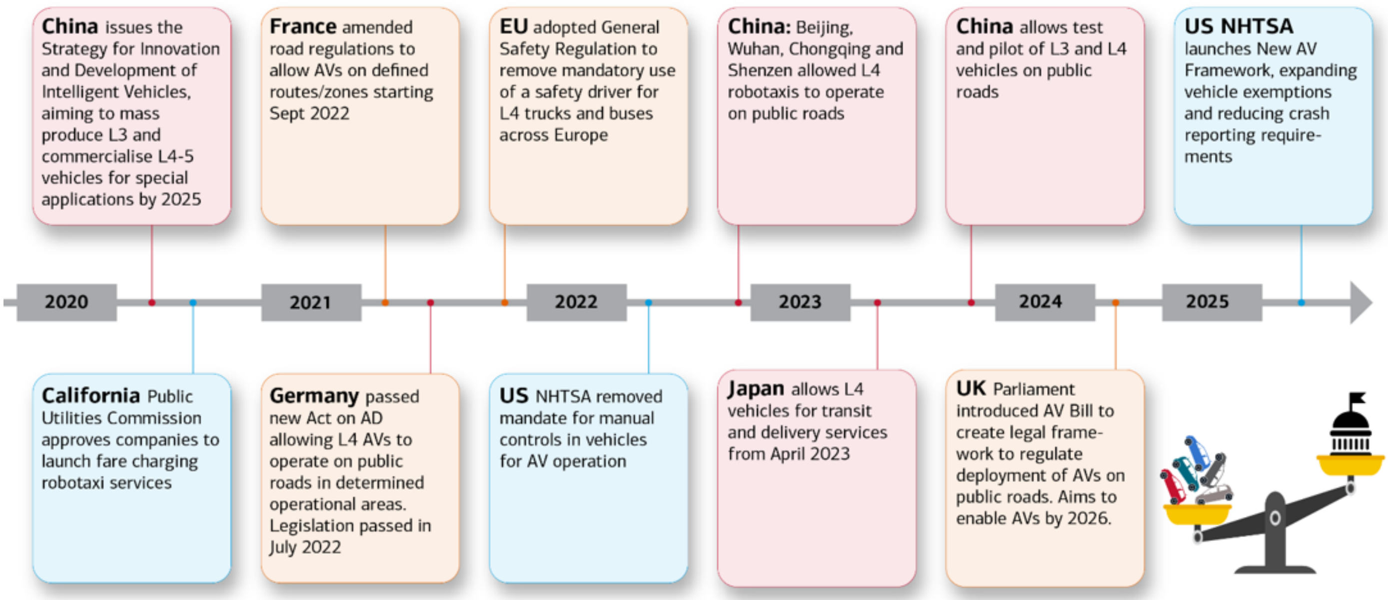
Several countries are beginning to create standards and regulatory frameworks required for AVs to operate commercially, but much fragmentation remains within countries and internationally (Exhibit 6). This poses both an opportunity (to launch commercial AV services in select locations already) and a challenge to AV operators. The lack of harmonious regulation and standards potentially limits the scalability and replicability of the business model, leading to operational inefficiencies, litigation and insurance risks.

From “tech wars” to “autonomy wars”

The increasing emphasis on the strategic geopolitical importance of AV technologies could accelerate the necessary frameworks and conditions required for the manufacturing and operation of AVs. For example, the US Automated Vehicle Framework was amended in 2025, relaxing rules to make it easier for companies to deploy AVs on public roads. Competition with China was cited as the key rationale, as several China AV companies begin expansion internationally. What’s becoming clear is several countries see AV technology not only as strategic importance for geopolitical and commercial global competitiveness.

Exhibit 6: The US, China, Japan, and three European countries already have legal frameworks in place for the operation of autonomous vehicles, aiming to enable commercial deployment

Multiple legal frameworks and autonomous vehicle regulations are already in place across the globe



Source: BloombergNEF (BNEF), BofA Global Research

NOTE: AD = autonomous driving, EU = European Union, NHTSA = National Highway Traffic Safety Administration

BANK OF AMERICA INSTITUTE

Peak Car by 2035?

AVs could lower the passenger car fleet, but increase miles travelled

The future size of the global car fleet could be defined by the adoption of AVs. High adoption could significantly reduce total cars on the road if they’re able to be accessed cheaply, reliably and on demand – increasing the share of higher utilized shared vehicles at the expense of privately owned vehicles. Per BNEF, the global passenger car fleet could peak in 2035 and remain flat to 2050, but in a high AV adoption scenario that number could fall by as much as 23% from 2025-50. Vehicle miles travelled, however, are expected to continue growing, assuming the rise in AVs reduces the price paid per mile. The 12 trillion miles travelled by cars annually in 2024 could increase by 21% 2035 and 54% to 2050, with an increasing share of robotaxi, shared and privately owned AV miles.

Contributors

Vanessa Cook

Content Strategist, Bank of America Institute

Sources

Martyn Briggs

Equity Strategist, BofA Global Research

Haim Israel

Equity Strategist, BofA Global Research

Lauren-Nicole Kung

Equity Strategist, BofA Global Research

Felix Tran

Equity Strategist, BofA Global Research

Ming Hsun Lee

Analyst, BofA Global Research

Joshua Shanker

Analyst, BofA Global Research

Disclosures

These materials have been prepared by Bank of America Institute and are provided to you for general information purposes only. To the extent these materials reference Bank of America data, such materials are not intended to be reflective or indicative of, and should not be relied upon as, the results of operations, financial conditions or performance of Bank of America. Bank of America Institute is a think tank dedicated to uncovering powerful insights that move business and society forward. Drawing on data and resources from across the bank and the world, the Institute delivers important, original perspectives on the economy, sustainability and global transformation. Unless otherwise specifically stated, any views or opinions expressed herein are solely those of Bank of America Institute and any individual authors listed, and are not the product of the BofA Global Research department or any other department of Bank of America Corporation or its affiliates and/or subsidiaries (collectively Bank of America). The views in these materials may differ from the views and opinions expressed by the BofA Global Research department or other departments or divisions of Bank of America. Information has been obtained from sources believed to be reliable, but Bank of America does not warrant its completeness or accuracy. These materials do not make any claim regarding the sustainability of any product or service. Any discussion of sustainability is limited as set out herein. Views and estimates constitute our judgment as of the date of these materials and are subject to change without notice. The views expressed herein should not be construed as individual investment advice for any particular person and are not intended as recommendations of particular securities, financial instruments, strategies or banking services for a particular person. This material does not constitute an offer or an invitation by or on behalf of Bank of America to any person to buy or sell any security or financial instrument or engage in any banking service. Nothing in these materials constitutes investment, legal, accounting or tax advice.