Future of Mobility

The technologies and trends driving innovation in the emerging mobility ecosystem

SVB Frontier Tech Practice

Executive Summary

The global transportation industry is ripe for disruption, as new technologies, modes and platforms are emerging.

The transportation industry is undergoing significant structural changes, brought about by a confluence of social, demographic, political, financial and technological forces. An emerging mobility ecosystem is bridging the gap between the digital and physical worlds, leveraging advances in fundamental hardware, artificial intelligence and communications.

As a result of these rapid changes, the way people and goods move from point A to point B will consist of technology-enabled, shared, multimodal, electric and autonomous transportation. This report takes a deep dive into the forces driving these changes, the players involved and the effect that the emerging mobility paradigm will have on the industry and the economy.

Report Highlights

- If the global transportation industry were a country, it would be the third-largest economy in the world by annual revenue, behind only the US and China.
- Although still in development, autonomous vehicle systems and hardware have received more than $20 billion in funding over the past decade.
- By 2025, 25% of cars sold will have electric drivetrains, up from 5% today.
- We expect maturation in electric vehicles in one to three years, shared and multimodal transportation in three to five years and autonomous vehicles in five to 10 years.
- We predict that the battle among ride-sharing companies, carmakers and technology giants will result in each settling on partnering in its respective area of expertise.

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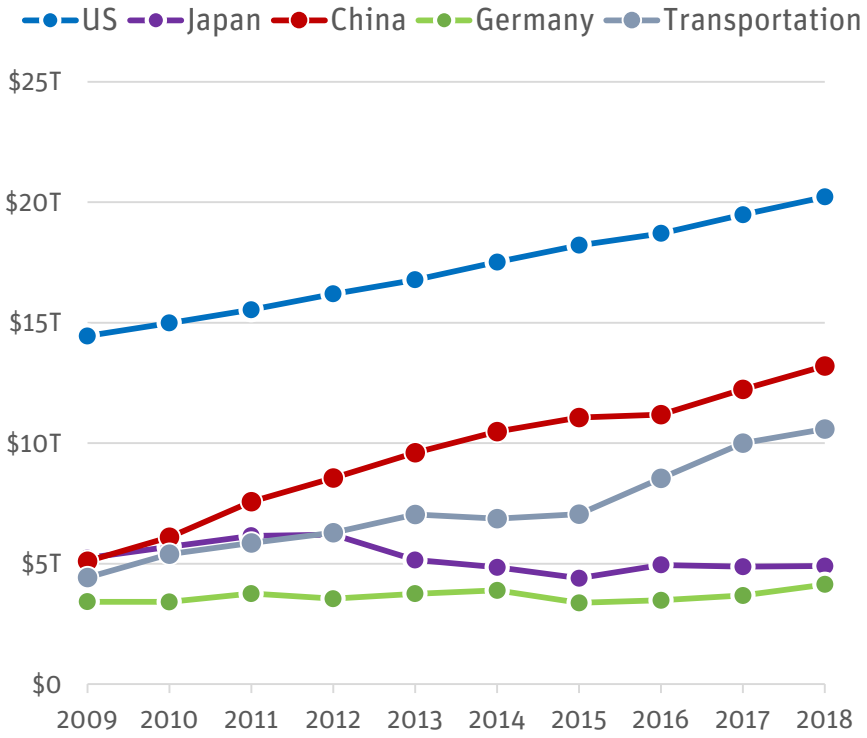
The Transportation Industry Today

Transportation Is Big Business

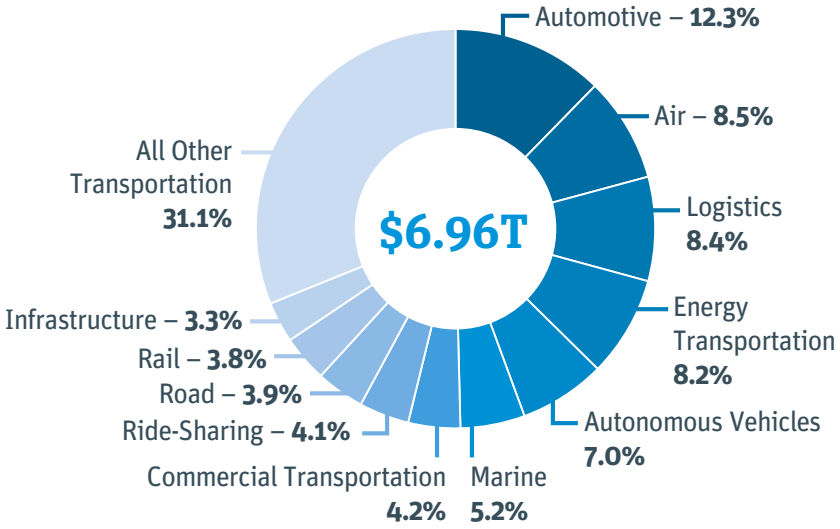
If the global transportation industry were a country, it would be the third-largest economy in the world by annual revenue, behind only the US and China.

Gross Domestic Product of the Four Largest Economies vs. Global Transportation Revenues



Note: For US, China and Germany, 2018 GDP data includes forecasted figure for Q4 2018.

Total Invested Capital in Transportation, by Sector — Trailing 10 Years

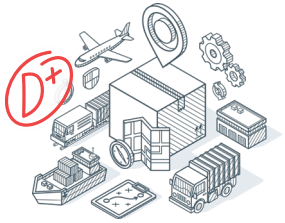


With **$20.2 trillion in total assets**, the global transportation industry is strongly tied to and influences many other major industries.

Source: S&P Capital IQ, PitchBook and SVB analysis

The World Is Ready for Change

Our current transportation networks have served us well for a long time, but no one can deny that the system is strained. As the global population increases and cities become more densely populated, these problems will only get worse if nothing is done to address them. People around the world are ready for a new mobility paradigm — one that fits their digital lifestyle and alleviates the issues associated with our current transportation systems.



Aging Infrastructure

In 2017, the American Society of Civil Engineers gave the nation's infrastructure an **overall grade of D+** on its Infrastructure Report Card. Key infrastructure categories, including aviation, roads and transit, all received individual **grades of D or lower**.[1]

Lost Productivity

Traffic is expensive. In the US alone, traffic congestion cost cities and drivers **$305 billion** in 2017. Census data shows that the American **commute is getting longer**, and the longest commutes in the nation are also the fastest-growing.[2]

Public Health

Nearly **40,000 people** in the US die each year in transportation-related incidents. There are also hidden costs, as air pollution and contaminants from transportation are indirectly linked with **respiratory and cardiovascular** health issues.[3]

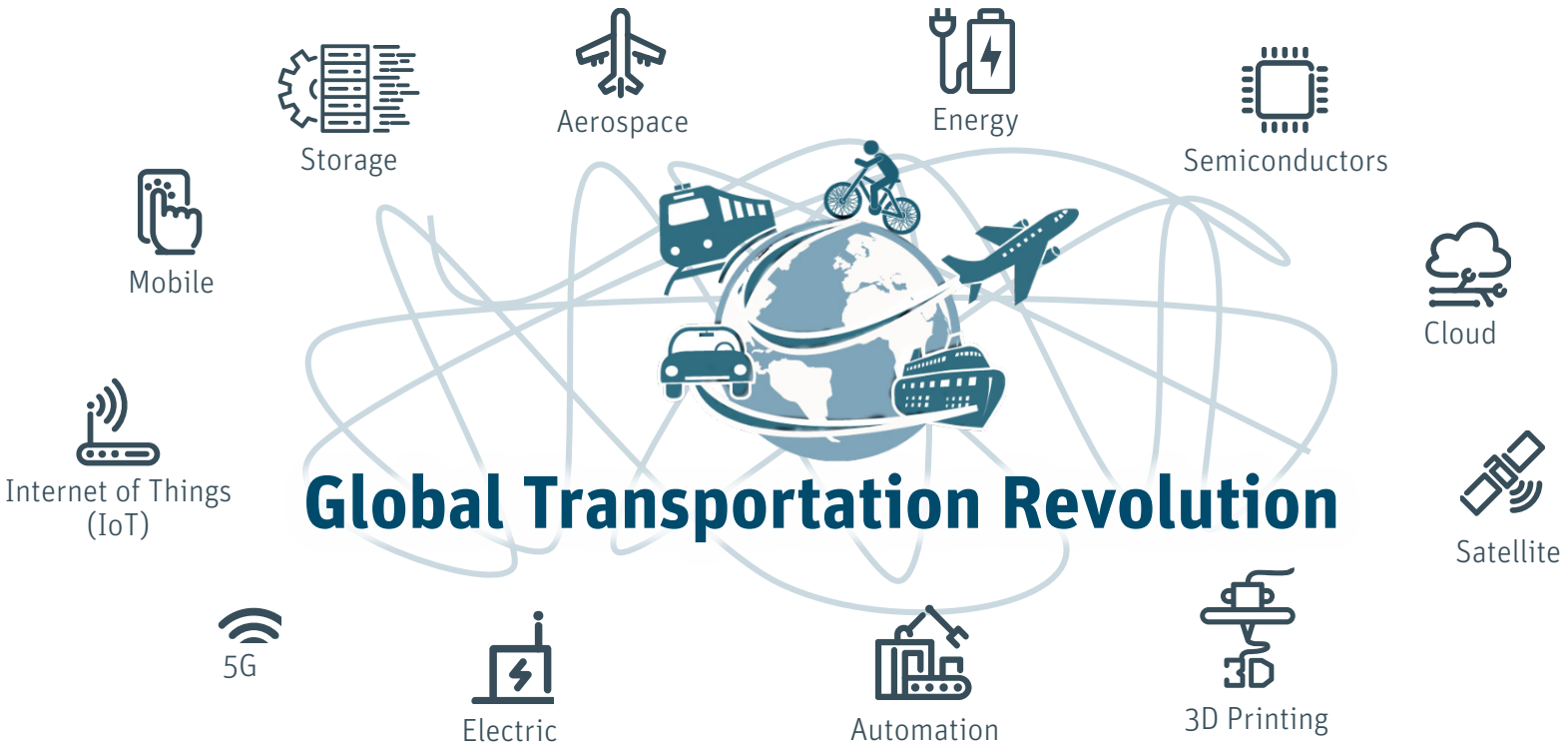
Environmental Impact

Twenty-two percent of global greenhouse gas emissions are attributed to the transportation sector. Noise is known to have harmful effects on delicate ecosystems, and **carbon monoxide emissions** contribute to steadily decreasing air quality.[4]

Source: (1) American Society of Civil Engineers, (2) INRIX Global Traffic Scorecard, (3) National Safety Council and (4) United States Environmental Protection Agency

The Technology Has Arrived

A confluence of technological advancements in various fields has allowed solutions to be developed to solve common problems in the transportation industry. From autonomous vehicles (AVs) and electric vehicles (EVs) to shared mobility platforms, new developments are happening every day.

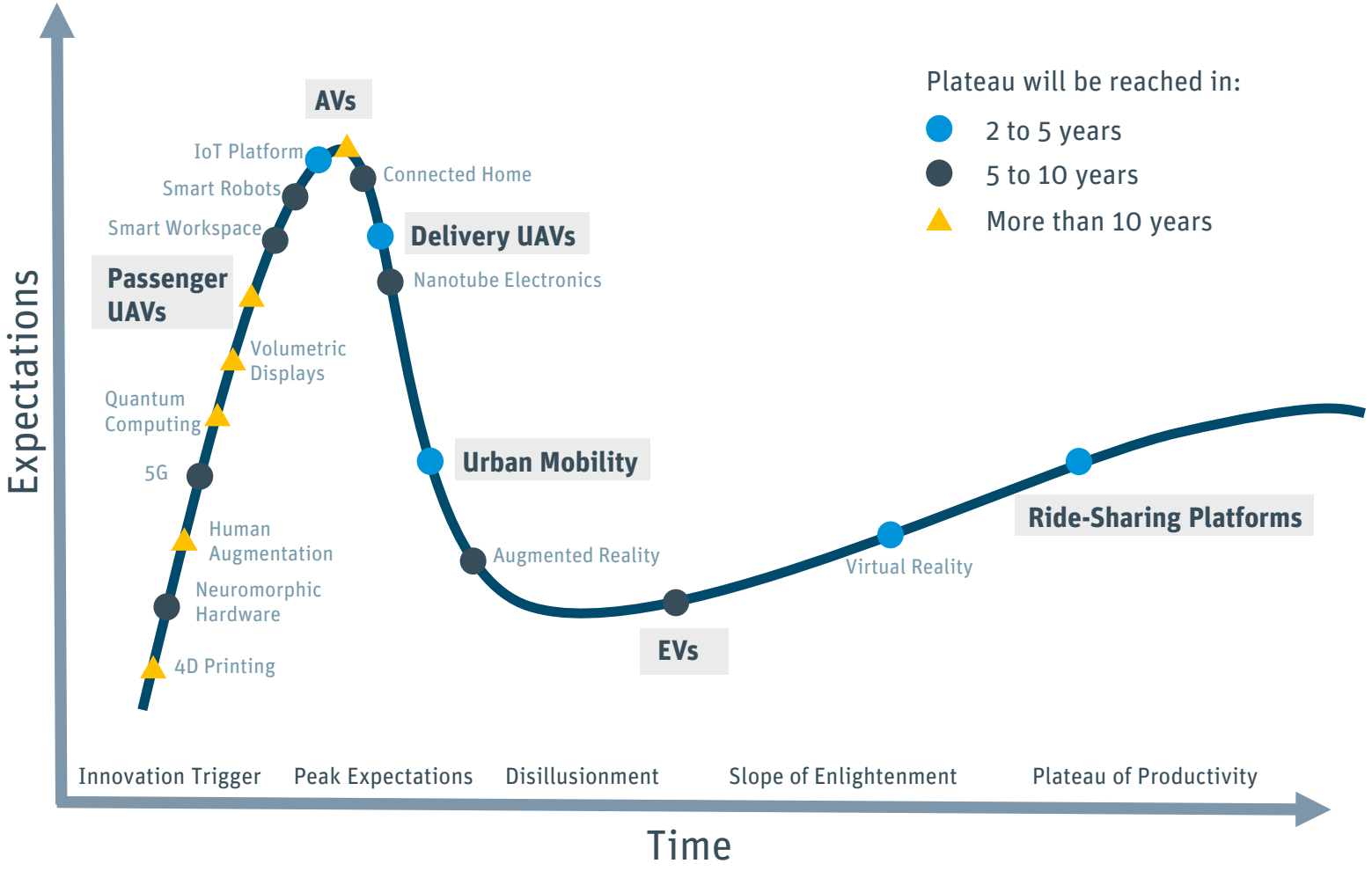


The evolution of the car is a perfect example of this greater technology-driven phenomenon. For example, 90 percent of innovations and new features in the automotive industry are driven by software and electronics, which account for 35 to 40 percent of an average car's production cost. Advances in drivetrain technology, lightweight materials, vehicle-to-vehicle communication and AI are the leading areas of innovation.

Source: McKinsey & Company and SVB analysis

Adoption Will Take Time

The technology is here, but it will take time to mature. Some transportation technologies are already online and will get more advanced with time, such as ride-sharing platforms, personal electric vehicles (PEVs) and unmanned aerial vehicles (UAVs).

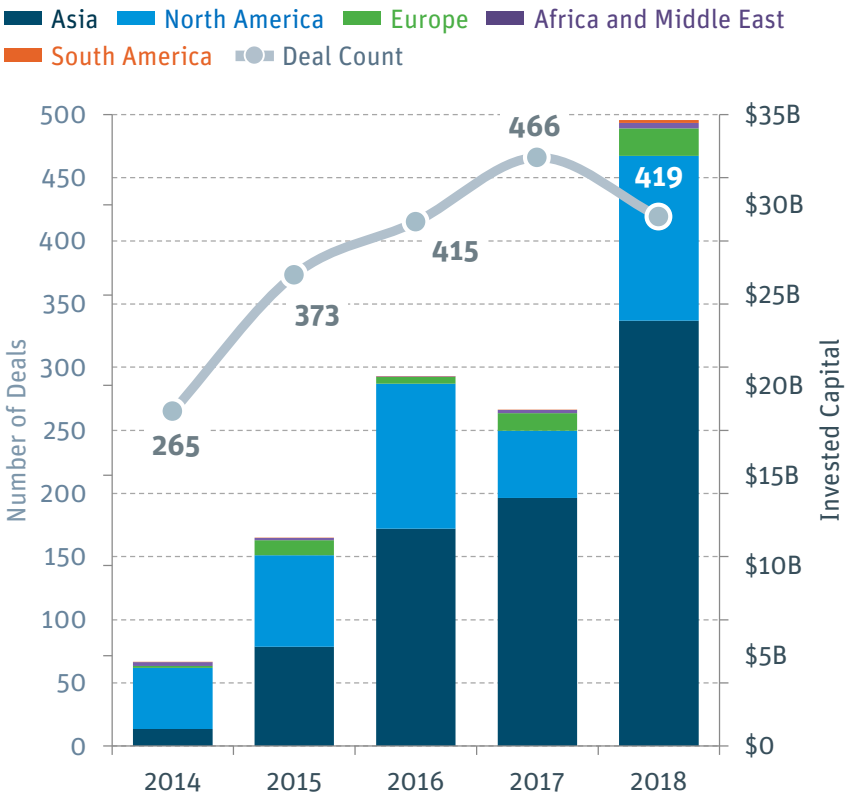


Source: Gartner and SVB analysis

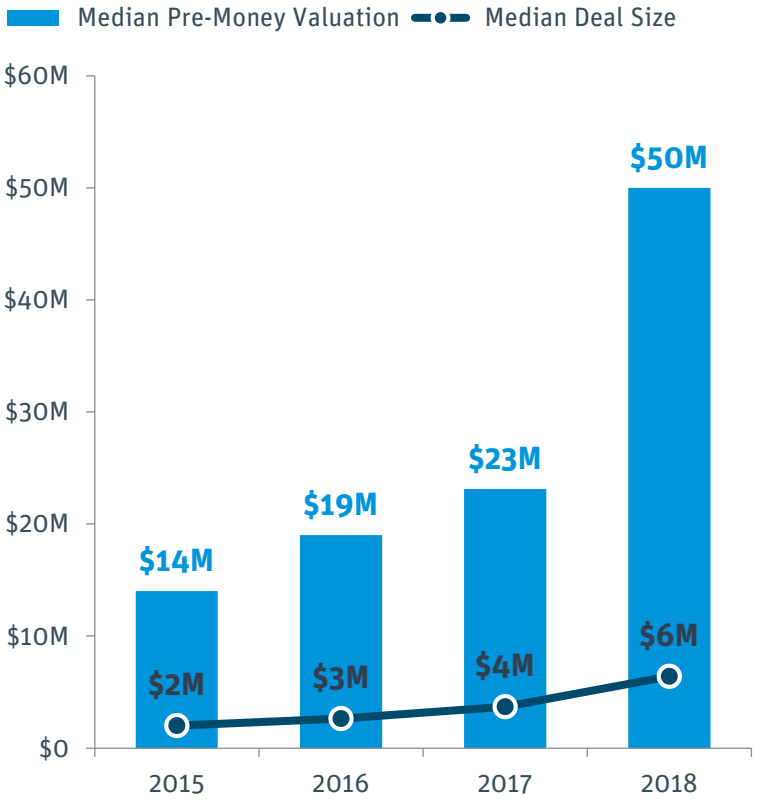
A Global Funding Wave

By Q4, 2018 venture capital (VC) investment in transportation startups neared $35B and is on track to double the amount of fundraising a year ago. The bulk of this capital was directed toward ride-sharing platforms such as Uber, Didi, Grab and Lyft, which have all raised $1B+ mega-rounds in 2018. At the same time, median pre-money valuations for transportation-related startups have almost doubled to $50M in 2018, up from $23M the year prior.

Venture Financing in Transportation Technology: 2014–2018



Transportation Technology: Median Pre-Money Valuation and Median Deal Size 2015–2018



Source: S&P Capital IQ, PitchBook and SVB analysis

The Four Pillars of Mobility

What Are the Four Pillars of Mobility?

There are four key areas in which innovation in transportation is taking place. The future mobility paradigm will consist of autonomous systems and powerful electric drivetrains across a wide variety of modes, most of which will be seamlessly shared, connected, safe, convenient, personalized and on-demand.

Shared

The mobility platform of the future will build on the idea of distributed and shared mobility. Fewer people will own cars and instead will opt to use on-demand services, enabling greater vehicle-use efficiency and less congestion.

Multimodal

The future of mobility will consist of a highly flexible platform comprising various modes of transportation, each providing a unique solution. Every leg of a journey will come with an array of transportation options.

Electric

The first electric car was built in 1832, and we've come a long way since then. Today, EVs have better power, speed, and safety compared with gas-powered cars, and they're better for the environment.

Autonomy

Although still in development, AV systems and hardware are heavily researched and have received more than $10B of funding. Large automakers and tech giants are racing to build the first fully commercialized product.

Global Venture Capital Activity in Mobility*

Number of Startups:	242	Number of Startups:	72	Number of Startups:	448	Number of Startups:	202
Capital Invested:	$58.0B	Capital Invested:	$4.1B	Capital Invested:	$24.7B	Capital Invested:	$10.0B
Number of Deals:	574	Number of Deals:	151	Number of Deals:	986	Number of Deals:	398
Investors:	1,318	Investors:	362	Investors:	1,290	Investors:	848
Largest Deal:	$7.3B	Largest Deal:	$621M	Largest Deal:	$3.2B	Largest Deal:	$1.0B

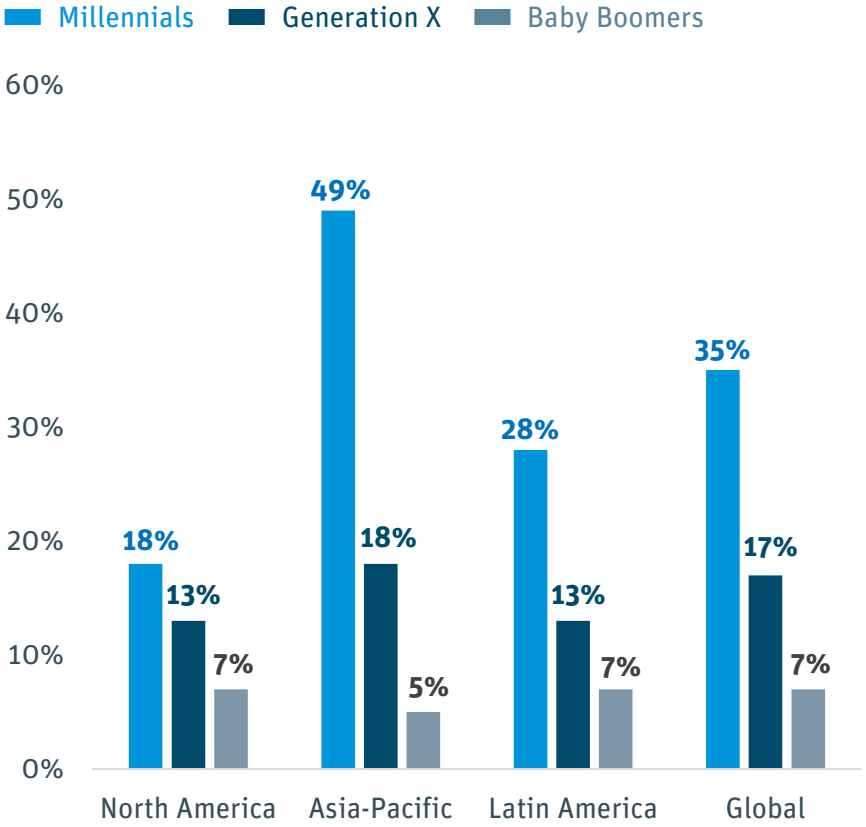
*Data for all companies within each PitchBook vertical, for prior 10 years
Source: PitchBook and SVB analysis

Shared Transportation

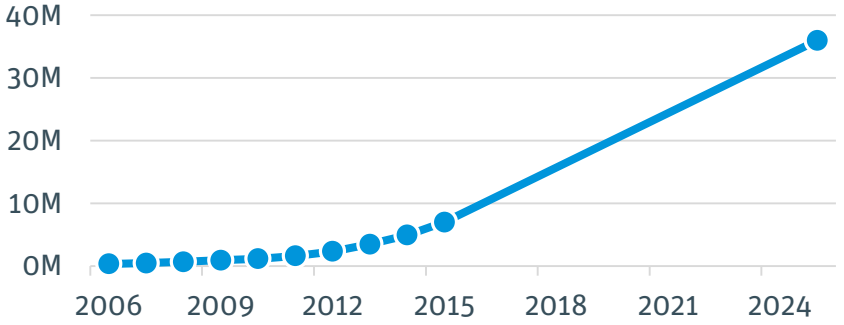
The Sharing Economy Hits Mobility

Shared transportation is being driven by demographic and social forces and technology. Some would argue that the biggest innovation in mobility was the invention of the smartphone. The success of ride-sharing companies like Uber, Lyft and Didi is a testament to that statement. Technology has also made sharing simple: from knowing when the next bus is coming, paying for small transactions effortlessly and being able to rent a car (or a seat) quickly, easily and cheaply.

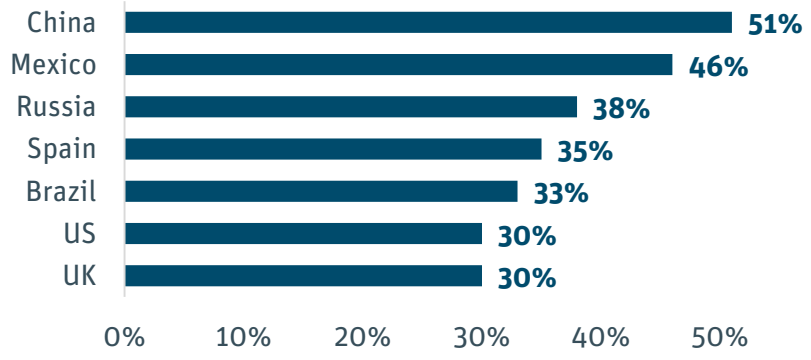
Willingness to Car-Share by Generation and Region



Number of People Worldwide Who Share Vehicles



Percentage of People Who Use Ride-Sharing Services by Country



Source: Goldman Sachs, Dalia Research and Statista

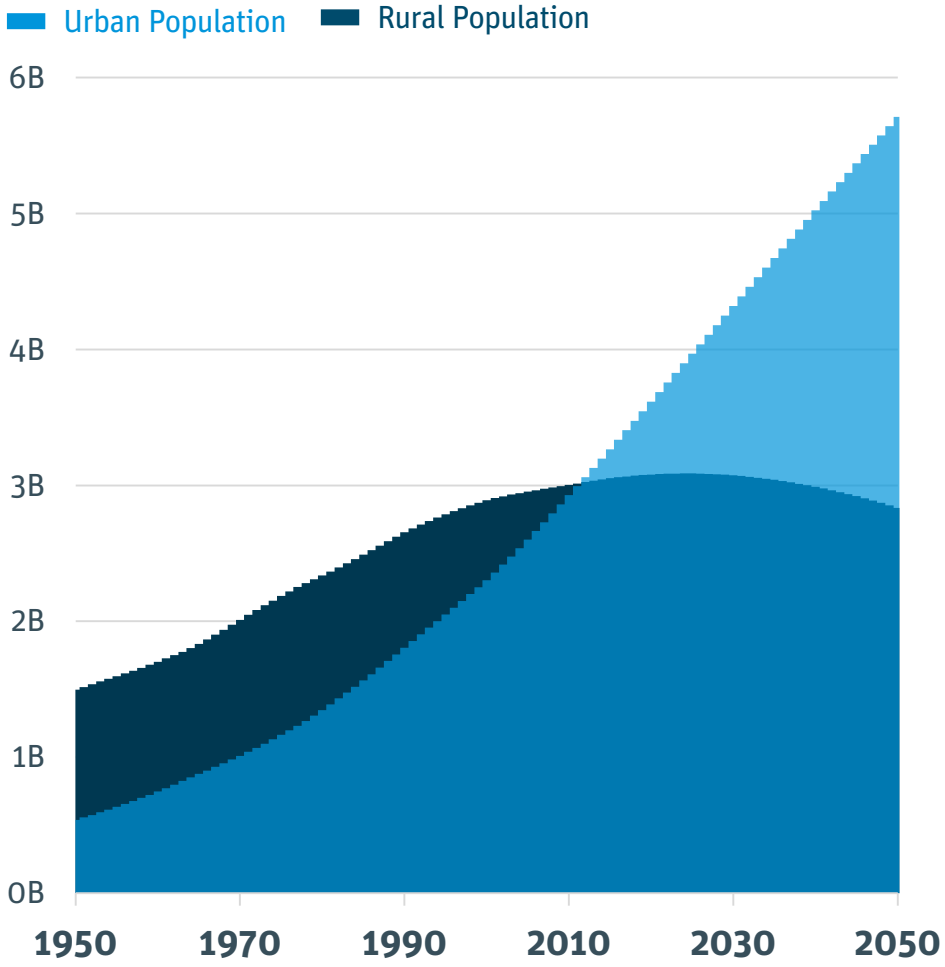
Increasing Urbanization Will Push Transportation to Its Limits

Three and a half billion people around the globe live in cities — and the United Nations says that the world population will double by 2050. Growing urban density is resulting in more "megacities" — those having a population greater than 10 million. Already, there are 47 megacities around the world, with 15 in China and 31 elsewhere in Asia.

The solution to the growing issues surrounding urban density is multipronged and includes a mix of affordable public transportation and efficient ride-sharing technology.

With increasing urban density, the role of ride-sharing technology to reduce congestion has never been greater. While AVs garner a lot of attention in the media, issues with traffic will continue to increase globally if AVs do not have robust ride-sharing capabilities.

Global Urban and Rural Population: 1950–2050

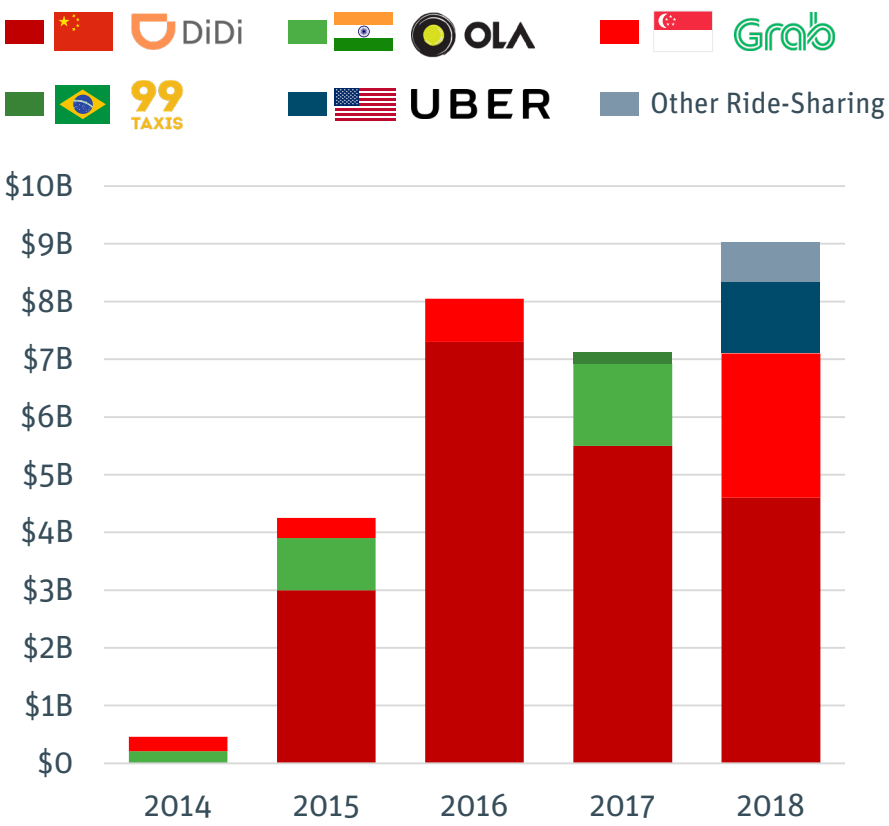


Source: UN World Urbanization Data and Wikipedia

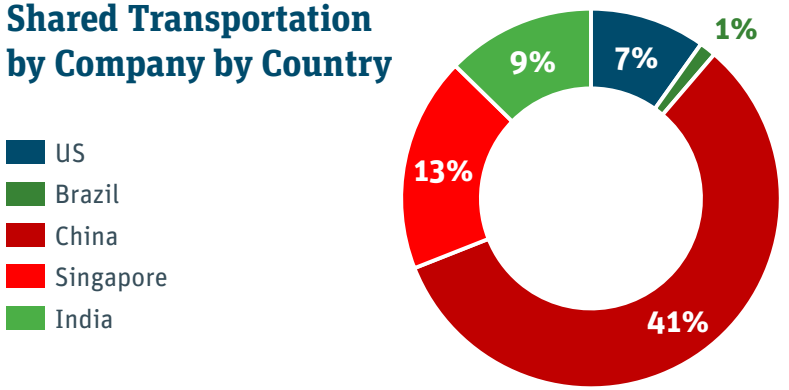
SoftBank Bets Big on Ride-Sharing

The Japanese conglomerate SoftBank has made waves by writing big checks. It has made multibillion-dollar investments in ride-sharing companies around the globe, including China, India and Brazil, while the number of companies is concentrated in the United States.

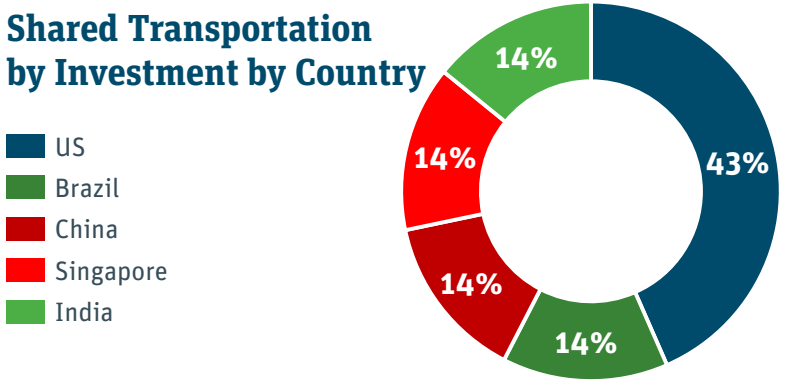
SoftBank Investments in Shared Transportation Companies: 2014–2018



SoftBank: Breakdown of Shared Transportation by Company by Country



SoftBank: Breakdown of Shared Transportation by Investment by Country

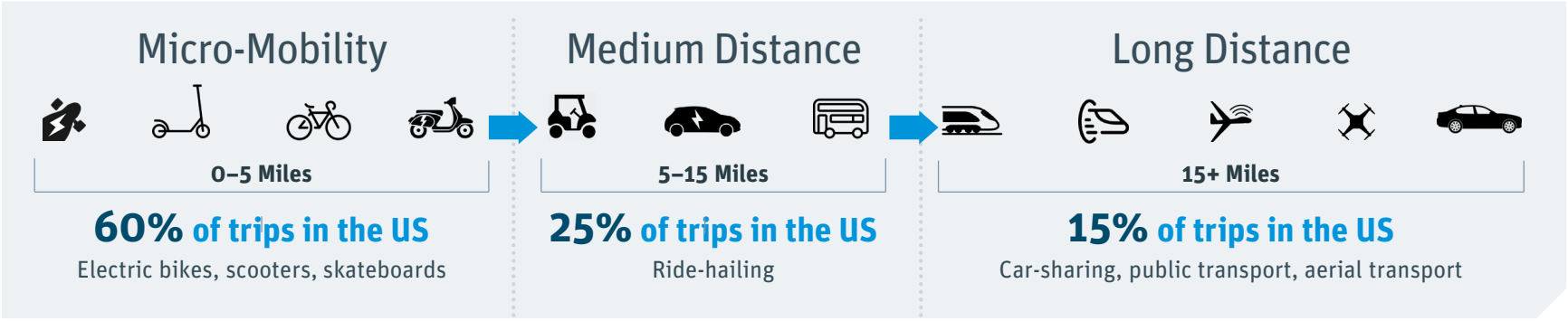


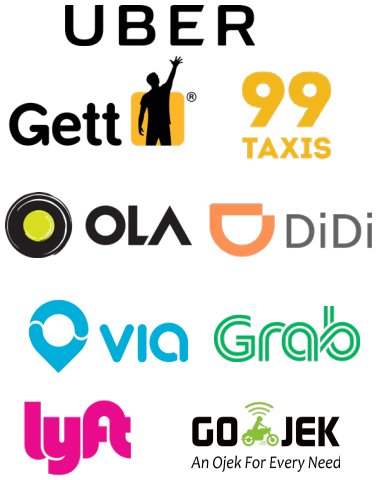
Source: PitchBook and SVB analysis

Multimodal Transportation

What Is Multimodal Transportation?

The concept of multimodal transportation is not new. In fact, much of freight transportation is "intermodal," meaning multiple modes of transportation are used without any handling of the freight itself when changing modes. The future of mobility will take this concept and apply it to human transportation.

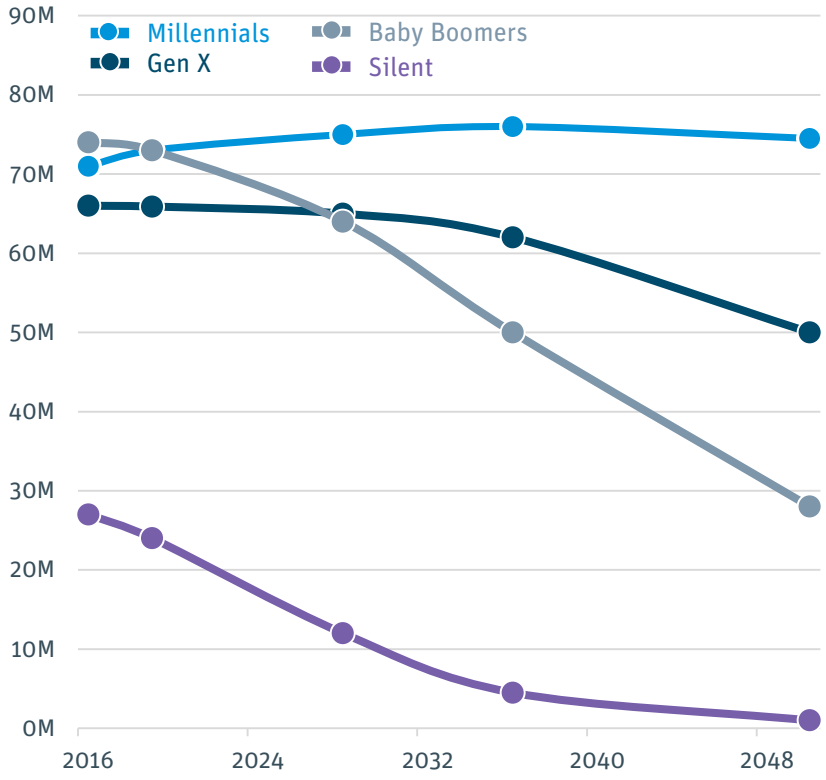




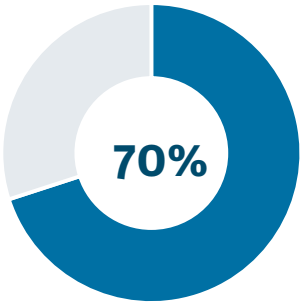
Millennials and Mobility: A Generational Shift

The millennial generation is the largest in US history and has unique mobility preferences. Millennials prefer the most practical transportation method for each trip. According to the study Millennials and Mobility, nearly 70 percent of millennials use multiple travel options several times per week. Car-sharing, bike-sharing and public transportation are all on the rise when compared with car ownership. This is largely due to smartphone applications, which allow transit users to be increasingly spontaneous and flexible with their travel decisions.

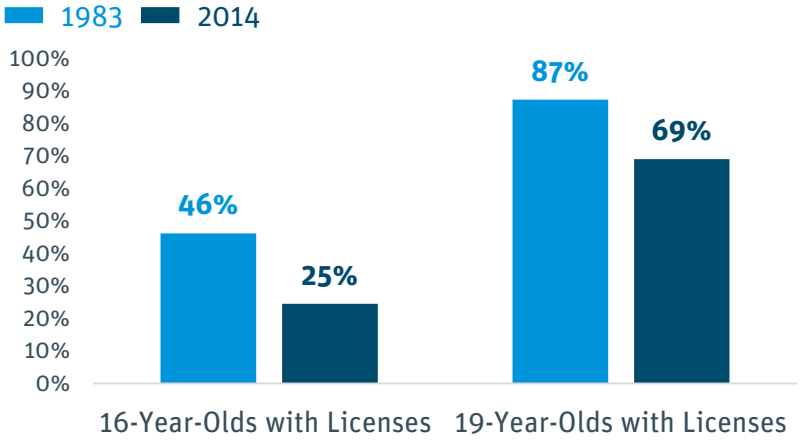
US Population by Generation: 2016–2050



Millennials Who Use Multimodal Transportation Several Times per Week



Teen Driver's License Rates: 1983 vs. 2014

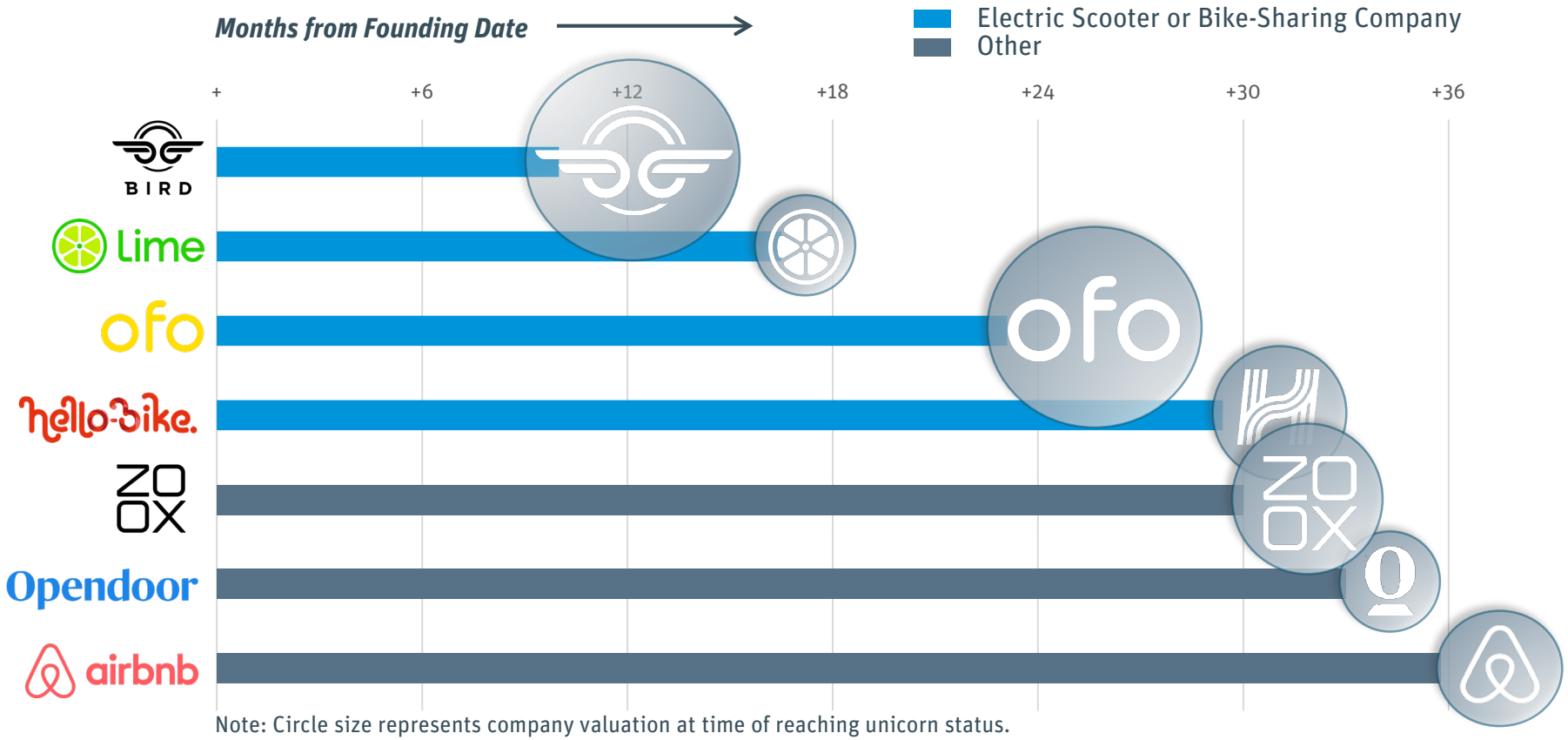


Source: Pew Research, American Public Transportation Association, University of Michigan Transportation Research Institute and SVB analysis

The Fastest Unicorns Ride Scooters

Four unicorns have rapidly emerged in the micro-mobility space: Ofo and Hellobike, both China-based bike-sharing platforms, and Bird Rides and Lime, US-based scooter-sharing services. Electric scooter startup Bird is the fastest company to reach a valuation of more than $1B. One of many scooter startups currently sweeping the US, Bird was last valued at $2.3B after closing $450M in Series C1 funding in June 2018.

Speed of Growth Based on Months from Founding Date to Achieving Unicorn Status



Note: Circle size represents company valuation at time of reaching unicorn status.
A unicorn is a privately held startup company valued at more than $1B.

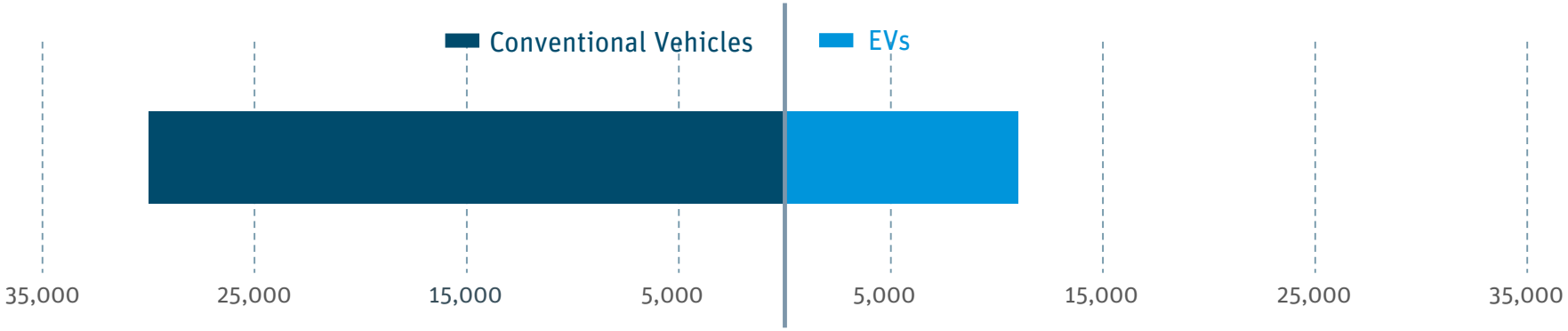
Source: CB Insights, PitchBook and SVB analysis

Electric Vehicles

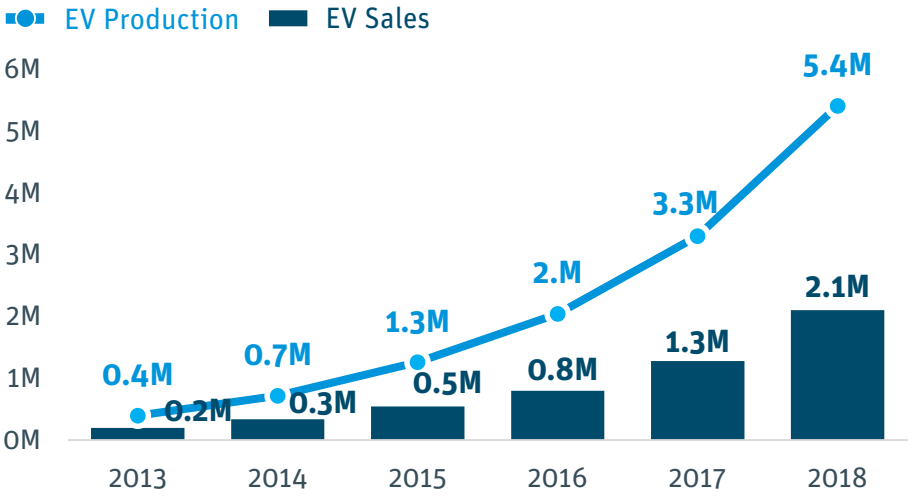
Less Is More for EVs

One catalyst driving innovation in EV technology is the fact that EVs have just one-third the amount of parts of conventional vehicles, which enables EV startups to compete with larger auto manufacturers on pricing.

Average Number of Parts: Conventional Vehicles vs. EVs



Number of EVs Produced and Sold Worldwide: 2013–2018



Worldwide EV production has been steadily climbing. On the supply side, the cost of manufacturing EVs has dropped significantly due to technological improvements in the manufacturing process.

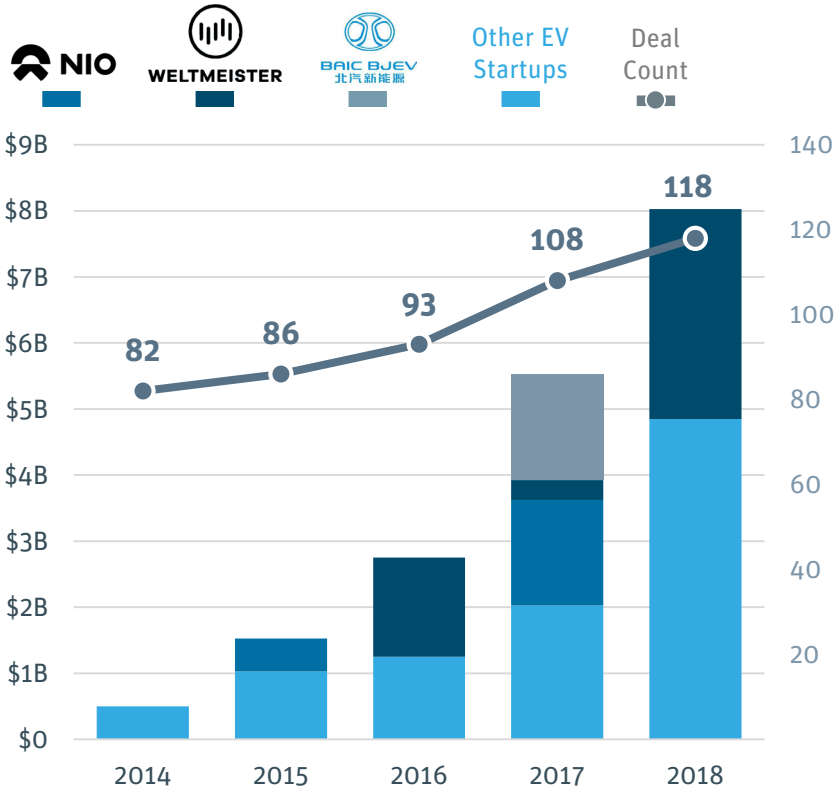
On the demand side, EV adoption is picking up as fuel costs and environmental concerns weigh on consumers. Furthermore, regulatory benchmarks are requiring automakers to manufacture more EVs. By 2025, 25 percent of cars sold will require electric drivetrains, up from 5 percent today.

Source: Goldman Sachs, EV Volumes, and SVB analysis

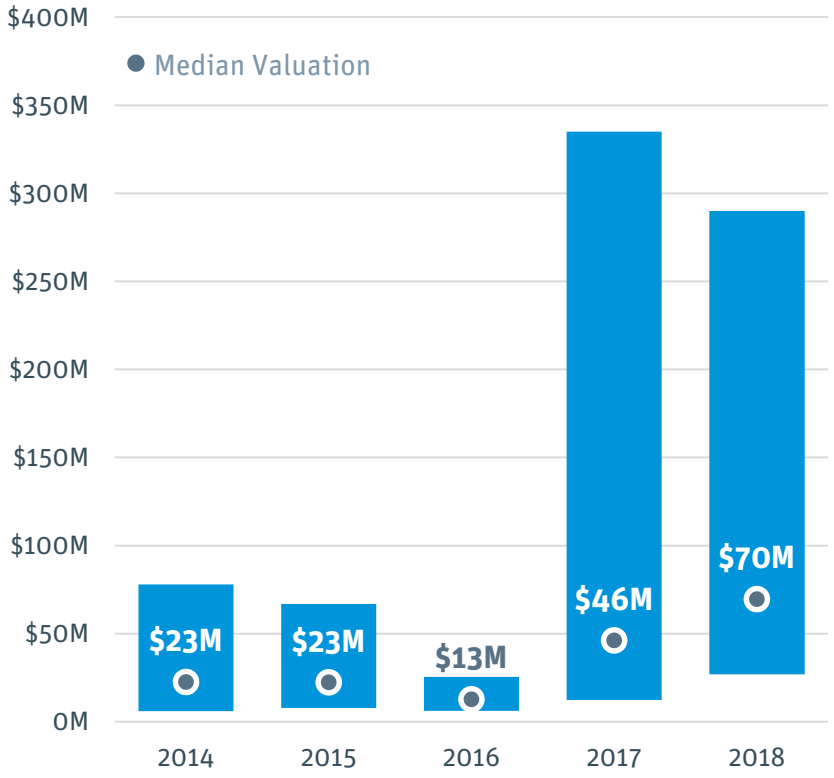
EV Activity Is Sparking

Investment activity in EV and battery technology has gained momentum in recent years as regulations require manufacturers to meet EV production targets and consumers gradually adopt hybrid and electric vehicles. Median pre-money valuations have climbed significantly in the past two years as venture and corporate investors in the US and China place significant bets on market leaders.

Venture Investment in EV Startups: 2015–2018



EV Startups: Pre-Money Valuation Ranges, 25th to 75th Percentile, 2014–2018

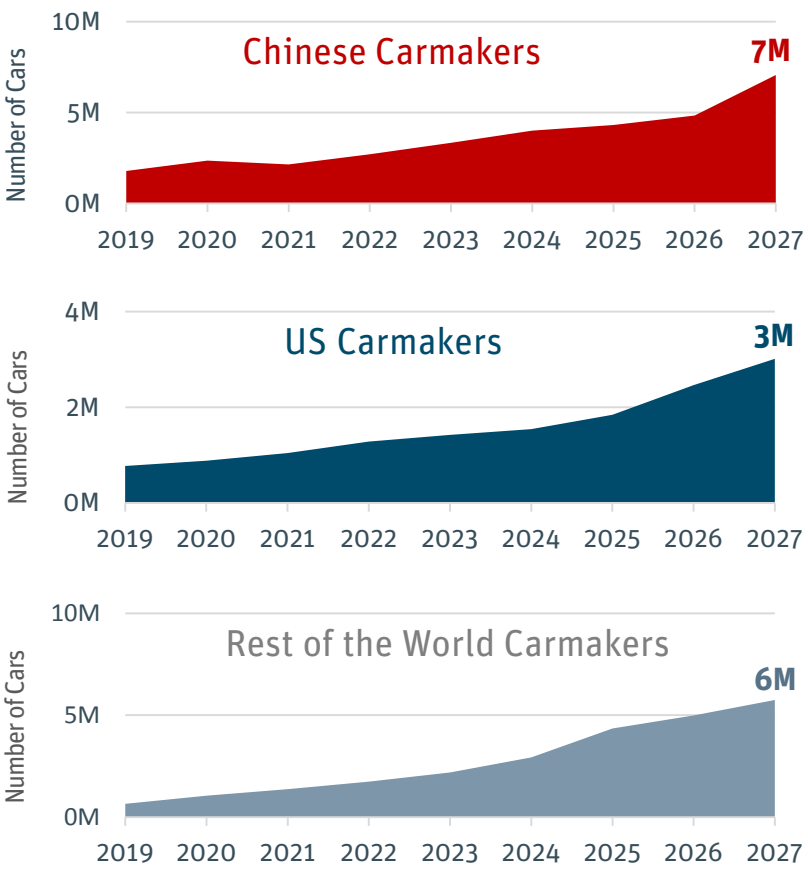


Source: PitchBook and SVB analysis

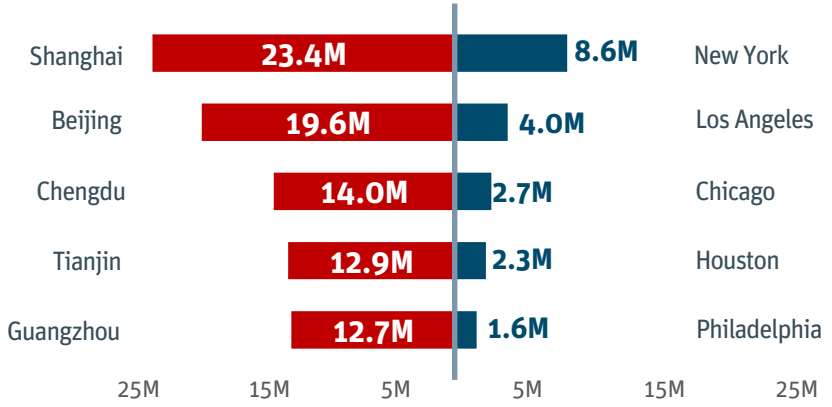
China Leads the Pack in EVs

With about two-thirds of the 3 million EVs worldwide made and used in China, it's clear that China is emerging as a global leader in EV development and adoption. This is no coincidence; the Chinese government has created a supportive regulatory environment and provided significant funding for EV startups.

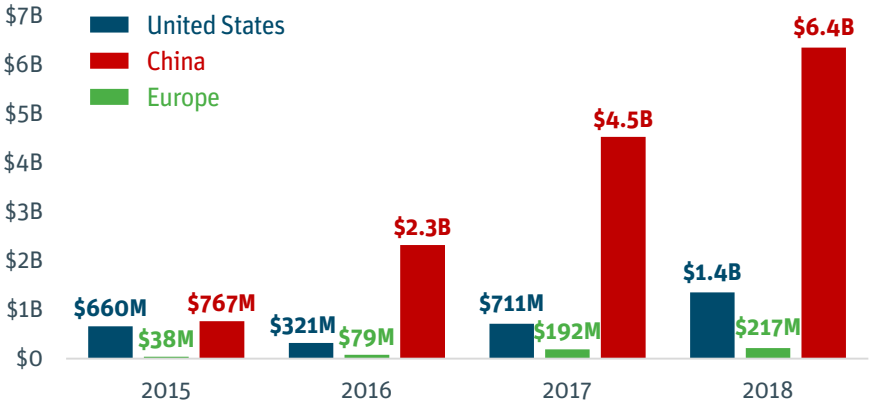
EV Sales Forecast by Global Region



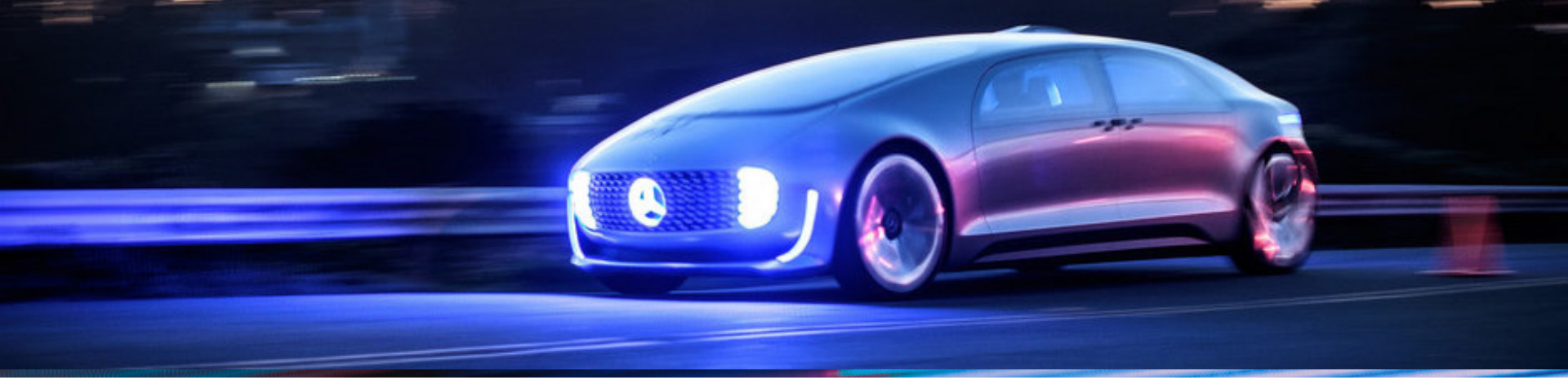
Population of Five Largest Cities: China vs. US



Global Venture Investment in EVs: 2014–2018



Source: The World Bank, Bloomberg, PitchBook and SVB analysis



Autonomous Vehicles

The Technology of Autonomy

The technology behind autonomy is complex, consisting of a patchwork of sensors and systems that allow the vehicle to receive and react to information from its surroundings. Progress in AV technology is the result of years of engineering and computer science research bridging various fields, as well as robust funding from venture and corporate investors.

Sensors and Cameras

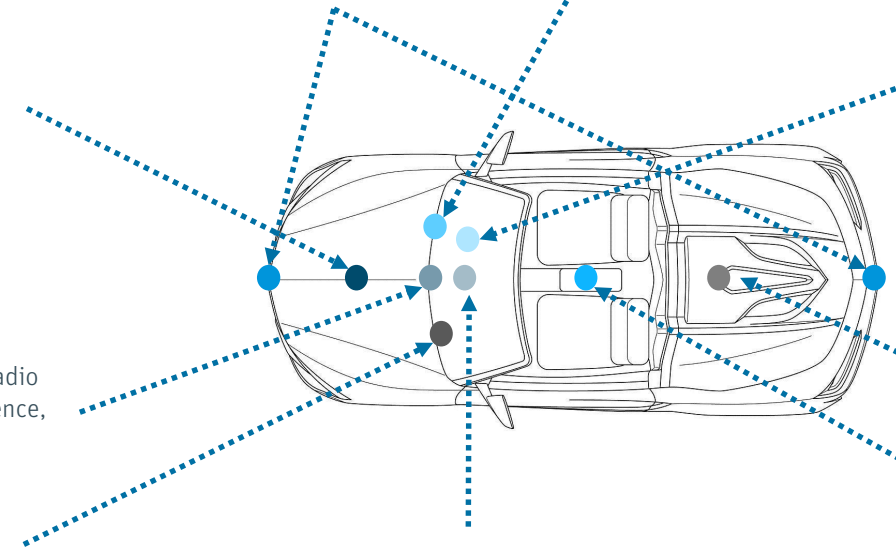
Data about the vehicle's surroundings are captured by onboard sensors and cameras, allowing precise movements in environments that are constantly changing.

Cloud-Based Data Processing

Real-time telemetric data is hosted on cloud-based servers, allowing the vehicle to process vehicle speeds and surrounding-car proximity.

Connectivity

All the systems onboard are networked, communicating with other vehicles and surrounding objects. This allows for adjustments due to changing weather or road conditions.



AI

Deep-learning algorithms enable the vehicle to quickly adapt to changing circumstances and continuously learn from new environments and situations.

Millimeter-Wave Radar

Millimeter-wave radar uses radio waves to determine the presence, distance and velocity of surrounding objects.

Machine Learning

AI systems improve vehicle performance without the need for continual reprogramming, aided by frequent and automatic software updates via the cloud.

LiDAR

Light Detection and Ranging technology senses traffic and vehicle brake lights. These sensors can even detect road conditions based on changes in the amount of light being detected on the road.

High-Performance GPS

Geosynchronous and low-earth orbit satellites track location down to a few feet, helping guide the vehicle to its destination.

Local Data Processors

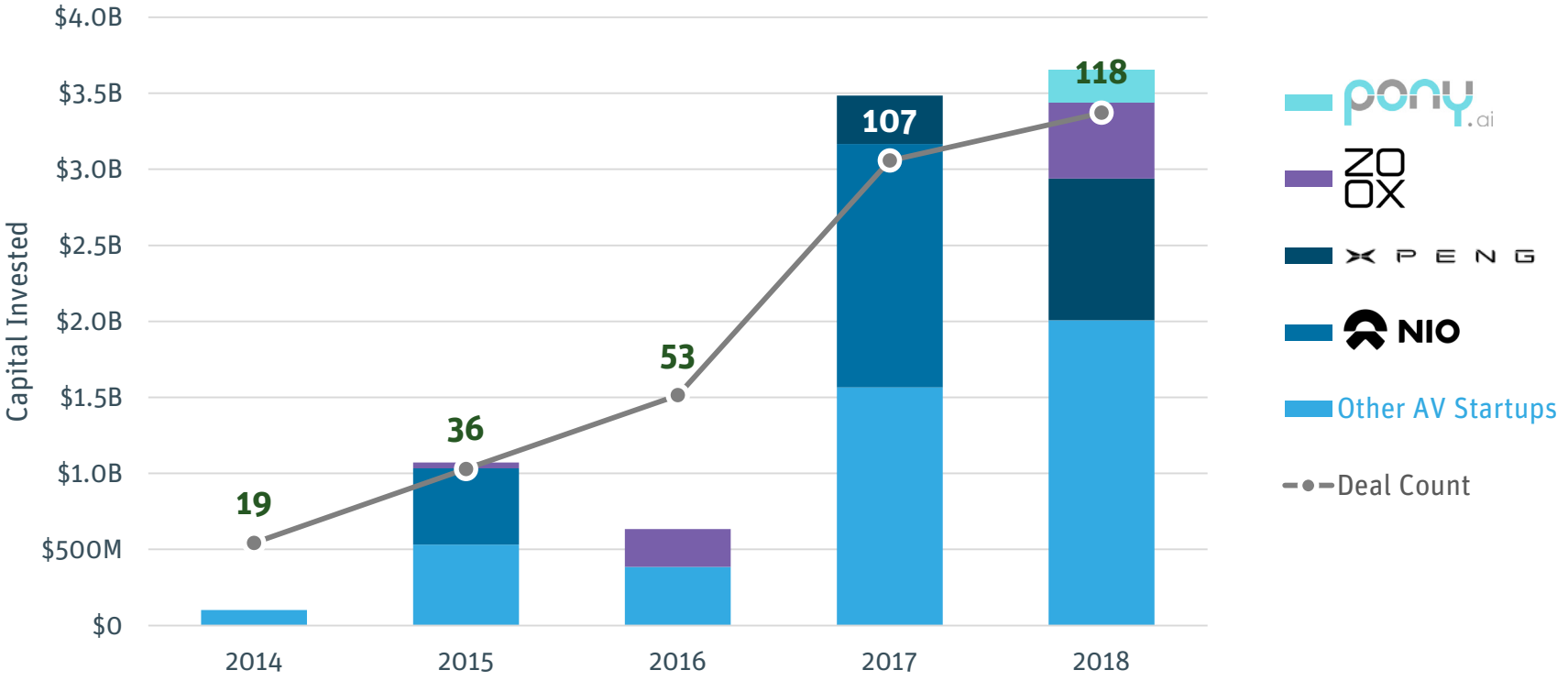
Onboard computers with specialized chipsets and software automatically perform real-time calculations with terabytes of data, enabling critical decision-making in milliseconds.

Source: MIT Technology Review and SVB analysis

Funding in Autonomy Dominated by Large Rounds

In 2015, Uber first made its interest in self-driving cars public when it hired 40 researchers and scientists from the National Robotics Engineering Center at Carnegie Mellon University. Following Uber's decision to invest in autonomy, the company raised nearly $10B in venture investment, and several AV startups followed suit with massive rounds of their own, making rounds less than $100M seem relatively small.

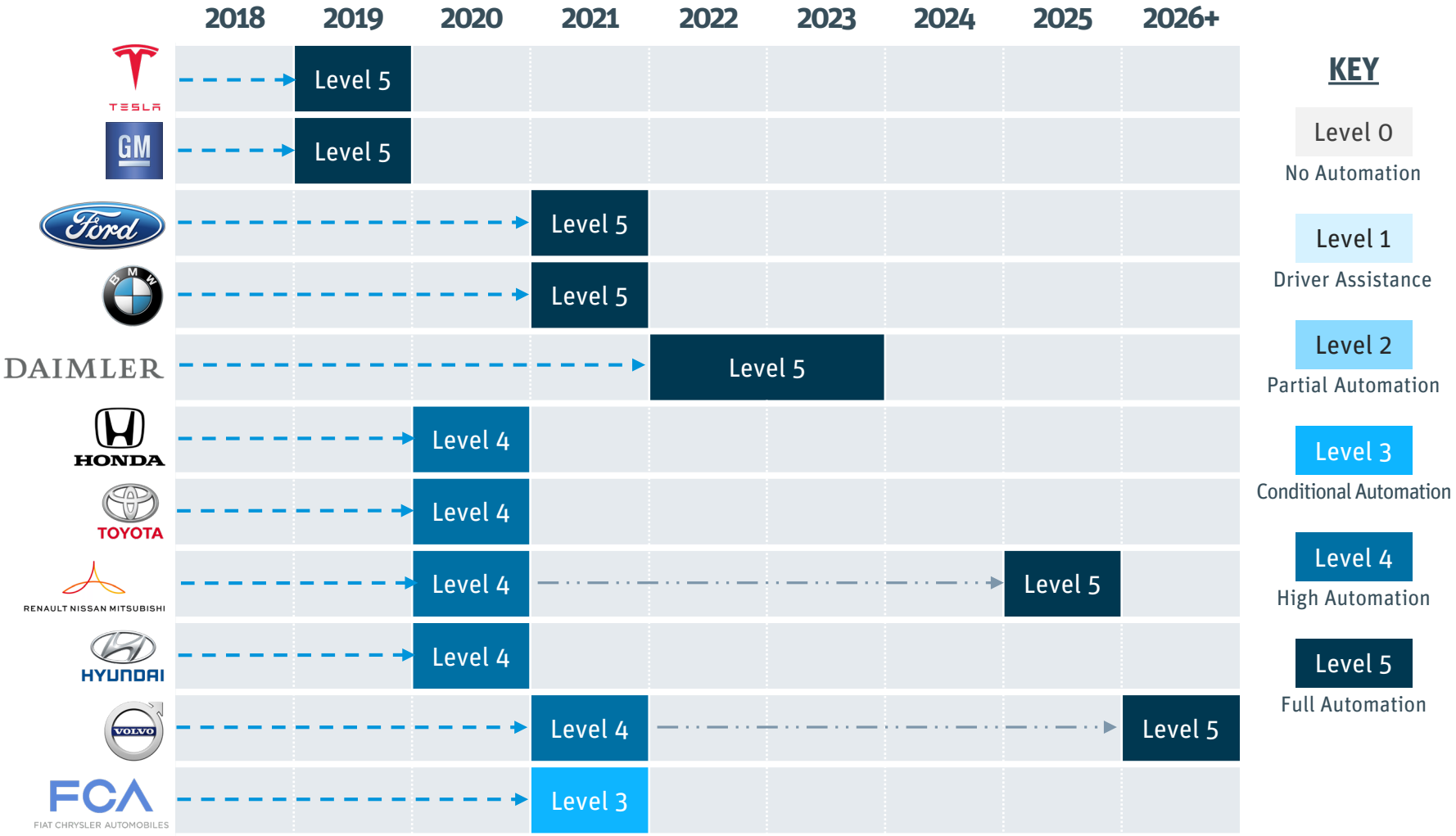
Global Venture Investment in Autonomous Vehicle Companies, except UBER: 2014–2018



Source: PitchBook and SVB analysis

The Race Is On

Legacy automakers are racing to release a commercial AV. Many have announced their timelines publicly, but who will be first?



Source: Emerj and SVB analysis

The State of AV Regulations

A regulatory environment that supports both consumers and companies is critical to the continued development of AVs. Federal regulations concerning AVs have been introduced, while state legislatures are passing laws that vary greatly from state to state. These distinctions will affect how states license AVs going forward, and they will set the stage for large differences in AV adoption across the US.

SELF DRIVE Act

Safely Ensuring Lives Future Deployment and Research in Vehicle Evolution Act*

Introduced → **Passed House** → Passed Senate → To President → Became Law

- Establishes a **federal advisory council** on AVs
- **Requires "safety assessment certifications"** by manufacturers
- Prohibits selling AVs unless manufacturer has a detailed **cybersecurity plan**
- Establishes that **federal government, not states, will regulate AVs**
- Manufacturers can't sell or in any other way introduce AVs unless they have a **data privacy plan**

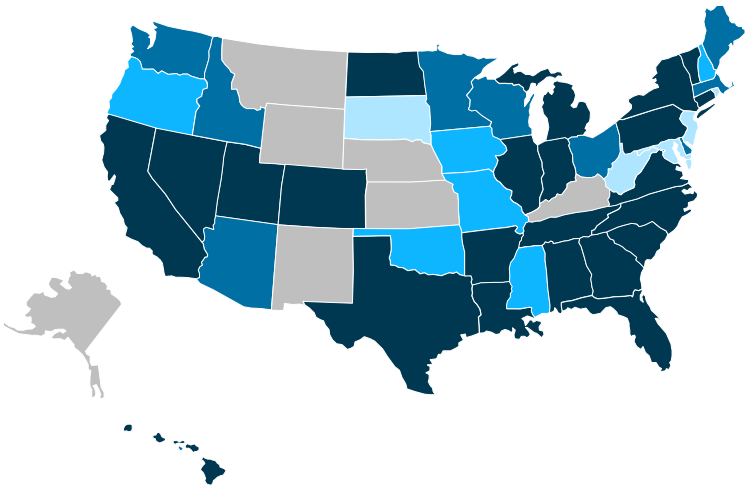
AV START Act

American Vision for Safer Transportation Through Advancement of Revolutionary Technologies Act*

Introduced → Passed House → Passed Senate → To President → Became Law

- Addresses conflicts with current **federal vehicle safety standards** (e.g., old regulations that require a steering wheel)
- Requires manufacturers to produce **safety evaluation reports**
- Establishes a **technical advisory board**

Regulation by US State



- Law Passed
- Executive Order
- Pending
- All Failed
- None Considered

*Progress as of Q4 2018

Source: Congress.gov, National Conference of State Legislatures, Brookings Institute and SVB analysis

Who Will Own the Mobility Platform of the Future?

Ride-Sharing Companies?

An interesting dynamic is emerging among auto manufacturers, ride-sharing leaders, large tech companies and startups to actively "invest" in the future transportation landscape, but because there is so much uncertainty, companies are looking to hedge their bets by partnering, investing and acquiring across a number of different verticals.

	Uber	Lyft	DiDi
Autonomous	Developing their own self-driving car technology Otto: $680M acquisition Partnering with OEM Volvo	Partnering with Waymo, Google's self-driving car division Partnering with Ford Building self-driving tech in partnership with Magna	Developing their own self-driving car technology Partnering with Volvo to co-develop a fleet
Multimodal	Lime: $335M Series C Jump Bike: $250M acquisition Partnering with NASA to develop UberAIR	Motivate: $250M acquisition	Partnering with Ofo and Bluegogo, bikes offered within Didi app
Shared	Continuing to develop their own ride-sharing technology	Continuing to develop their own ride-sharing technology	Continuing to develop their own ride-sharing technology

KEY

- BUY
- BUILD
- INVEST
- PARTNER

Source: PitchBook and SVB analysis

Carmakers?

It will be almost impossible for any one company to offer a full-stack solution, but control is something that everyone is cautious about giving up. It might seem that OEMs would be in the best position, but the disciplines required in this new high-tech era conflict with the more traditional OEM culture, while recruiting the best talent will be a challenge without the right infrastructure and compensation structures.

	Ford	BMW	GM
Autonomous	Developing their own self-driving car technology Velodyne Lidar: $150M Series A Civil Maps: $6.6M Seed Autonomic acquisition Argo AI acquisition	Developing their own self-driving car technology Blackmore Sensors Innoviz — solid-state LiDAR Collaborating with auto supplier Magna	Investing $1.1B to develop their own technology Partnering with SoftBank Cruise Automation: $1B acquisition
Multimodal	Partnering with Daimler on smart mobility network Partnered with Motivate on the Ford GoBike program	Partnering with Daimler on smart mobility network	Partnering with Daimler on smart mobility network Partnering with Zagster bike-sharing platform
Shared	Lyft: $1.7B Series H Canvas acquisition (vehicle leasing platform)	Partnering with Daimler on a "Joint Mobility Service" Purchased 50 percent stake in car2go rental platform DriveNow: $260M acquisition	Invested $500M in Lyft Yi Wei Xing: Series A in Chinese car-sharing platform

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Source: CB Insights, PitchBook and SVB analysis

Tech Giants?

This leaves the US and Chinese tech giants. With their talent, organization, expertise and most importantly data infrastructure, they have the best chance of tackling the technological hurdle of the future transportation paradigm. Who succeeds? On one hand, you have Google with Waymo, clearly the leader in autonomous tech. On the other hand you have Baidu and Alibaba, which primarily operate in a more supportive regulatory environment. *It's too close to call.*

	Google	Baidu 百度	Alibaba.com
Autonomous	Developing their own technology through Waymo Partnering with Chrysler	Partnering with bus maker King Long United Automotive Partnering with Meituan-Dianping for food delivery Developing their own technology, called Apollo	Developing in-car operating system — AliOS Partnering with China's largest automaker: SAIC Motor
Multimodal	Lime: $335M Series C	Developing a smart bike called DuBike	Partnering with Dongfeng Peugeot-Citroën Ofo: $2B acquisition
Shared	$1B investment in Lyft $1.5B investment in Indonesian ride-hailing company GO-JEK	$196M investment in Shouqi Limousine & Chauffeur Investment in Uber for an undisclosed amount	Developing carpool business called Gaode Map Investment in Southeast Asian ride-hailing company Grab

KEY

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Source: CB Insights, PitchBook and SVB analysis

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Matt Trotter heads SVB's Frontier Tech Group in San Francisco. Matt works with high-growth companies that create highly disruptive technologies in the businesses of transportation, industrials, aerospace, consumer electronics and semiconductors, with a focus on the convergence of hardware, software and data.

Matt is passionate about his customers' success, and it shows in the capital, connections and strategic counsel he provides to support their growth in hardware and deep technology — some of the most competitive business environments in the world. Matt is a graduate of California Polytechnic State University, where he played varsity soccer and majored business administration. Married and the father of an active young daughter, he still finds time to kick the ball around in a Sunday men's soccer league.

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