PitchBook

EMERGING TECH RESEARCH

Mobility Tech

Q3 2020

Contents

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This Emerging Technology Research report is updated on a quarterly basis to reflect changes in venture capital deal activity and other market related updates deemed valuable by the research analyst. The previous quarterly report can be accessed **here.**

Q3 2020 news and updates

VC ACTIVITY

- In Q3 2020, mobility tech companies raised $7.9 billion in aggregate VC across 167 deals, putting total deal value down 30% QoQ and 16.8% YoY.
- In the first three quarters of 2020, mobility tech companies raised $28.0 billion in aggregate VC across 616 deals, representing a 5.7% decrease in deal value from the same period last year.
- The electric vehicle and last-mile delivery sectors drove deal activity in Q3 as investors made large bets on emerging technologies within the mobility tech industry.
- Early-stage mobility tech startups have seen greater pressure as investors double down on “winners," contributing to a loftier median pre-money valuation YTD.

Q3 2020 DEALS

- **September 29:** Swedan-based lithium-ion battery maker **Northvolt** raised $600.0 million in a deal led by Goldman Sachs, **Volkswagen**, and Baillie Gifford.
- **September 24:** Colombia-based online food and grocery delivery app **Rappi** raised a $300.0 million Series E from T.Rowe Price, valuing the company at $3.5 billion.
- **September 9:** China-based electric vehicle maker **Weltmeister** raised $1.5 billion in a deal led by SIG and **SAIC**.
- **September 1:** Mexico-based digital auto marketplace app **Kavak** raised $397.2 million in a deal led by Greenoaks, SoftBank, and DST Global.

NEWS

- **Waymo**, a leader in the self-driving vehicle space, launched a fully driverless ridehailing service to the public within a geofenced area in Phoenix, Arizona, a city in the US.
- California’s governor signed an order banning sales of new gasoline cars by 2035 in the largest auto market in the US. New York appears to be following suit, as the New York State Senate has introduced a similar bill requiring new cars and trucks to be zero-emissions by 2035.
- Hydrogen-electric trucking company Nikola is facing investigations from the SEC and the US Department of Justice over misleading investors, raising some concerns around the trend of electric vehicle startups debuting on public markets through reverse mergers with special-purpose acquisition companies (SPACs).

TRENDS & OBSERVATIONS

- Tech investors are likely increasing their investments into mobility tech at the expense of traditional transportation incumbents, which are having to focus more on grappling with the pandemic and the shift to electric vehicles.
- Investors, corporates, and governments are doubling down on electrification with increased investments, partnerships, subsidies, and emissions reduction targets.
- Last-mile delivery has emerged as a focal point of corporate and VC investment, as demand for food, grocery, and convenience store delivery has spiked amid the pandemic.
- SPACs have emerged as a popular means to raise capital for electric vehicle companies, with autonomous vehicle companies beginning to follow suit.

Executive summary

The global transportation system has been profoundly affected by the COVID-19 pandemic. Carmakers have seen sales decline significantly and manufacturing grind to a halt. Airlines have been hit particularly hard by reduced air travel. Diminished ridership has strained public transportation system finances. In this environment, many startups focused on transportation technology have seen a negative impact to their business models. Social distancing and stay-at-home orders have resulted in ridership plummeting for ridesharing, micromobility, and carsharing companies as well. At the same time, key corporate financiers in the transportation space have seen their core business models suffer, weighing on their ability to invest in emerging technologies.

Although the mobility tech sector faces near-term challenges, we believe the long-term drivers for the sector remain intact. Next-generation mobility tech has given rise to several disruptive products and services, including ridesharing and delivery platforms, shared bicycle and scooter services, and connected and autonomous vehicle technology. Over the past few years, many of these emerging technologies and services have become ingrained in the everyday lives of consumers. As the world recovers from this crisis, we believe strong underlying demand for low-cost, convenient, and efficient mobility tech solutions will persist.

Since 2009, venture investors have poured $240.0 billion into mobility technology, with $28.0 billion invested in the first three quarters of 2020. In some cases, investment has been accelerated by the need for services such as contactless delivery and socially distanced commuting options. This report provides an overview of the mobility tech landscape and the products and services offered by the venture-backed startups within it. Venture funding has been key to fueling the growth of this sector.

Key takeaways

Diverging mobility tech company valuations: Funding toward late-stage mobility tech companies remains strong as investors prioritize "winners," raising late-stage valuations and putting pressure on angel-, seed-, and early-stage valuations. Although this is challenging time for early-stage mobility tech companies, we believe discerning financial and strategic investors with dry powder can opportunistically acquire or invest in technology and talent in the space at discount valuations.

Electrification and last-mile delivery drive investment: Mega-deals in the electric vehicle and last-mile delivery sectors propelled venture investment into mobility tech in Q3 2020. Investors have remained enthusiastic about electric vehicles given improving technology, strong regulatory tailwinds, and ongoing investment into electrification by incumbent automakers. Meanwhile, delivery companies continue to benefit from the pandemic-induced surge in online shopping and online restaurant and grocery delivery.

The electric vehicle SPAC frenzy: Several electric vehicle startups, including **Canoo**, Chargepoint, **Faraday Future**, **Fisker**, **Hyliion**, **Lordstown Motors**, Nikola Motors, **QuantumScape**, Romeo Power, and **XL Fleet** have announced plans to debut on public markets via SPAC reverse mergers, representing over $6 billion invested in 2020 so far. Because they offer quicker time to market and less scrutiny, SPACs are an attractive listing option for electric vehicles companies and, more broadly, startups that are highly capital intensive and in the pre- to early revenue stages. SPACs enable companies to mitigate market volatility and strike while the iron is hot. Investor enthusiasm for electrification is strong right now, and it is an opportune time for electric vehicle companies to raise capital from public market investors, as valuations in the space are high.

Tech giants are pulling ahead in the race to self-driving: We believe the current downturn has enabled tech companies to gain a foothold in the autonomous vehicle ecosystem, to the detriment of incumbent automakers. Many automakers are facing financial pressure stemming from the pandemic and have been forced to focus inward on their core businesses, leading to delayed projects and curtailed investments into long-term bets such as self-driving technology. Additionally, we expect incumbent automakers to remain preoccupied with the shift to electric vehicles as they prioritize investments over the medium to long term. Meanwhile, tech companies with large cash reserves and strategic interests in transportation are well positioned to invest heavily in autonomous vehicle technologies.

Micromobility poised to draw commuters from public transit: The e-bike and e-scooter industry could benefit in the long term as economic activity resumes and urban commuters remain wary of public transit. In the long term, micromobility could play an important role in helping cities incorporate social-distancing practices for commuters, while also solving existing issues related to congestion and emissions. The ongoing shift to swappable batteries, larger form-factor vehicles, and dynamic pricing could expand margins in the space significantly.

Online auto commerce startups boosted by pandemic: The coronavirus pandemic has catalyzed demand for contactless, flexible access to cars. Online auto commerce startups such as **Shift**, **Blinker**, and **Digital Motors** are poised to benefit from growth in this market as contactless car sales have many advantages over sales via traditional dealerships. Meanwhile, with international travel limited and airline travel viewed as risky from an

KEY TAKEAWAYS

infection perspective, road trips have been popular among vacationers, with contactless carsharing apps benefiting from the trend, such as those provided by **Turo** and **Getaround**. We expect incumbent automakers and dealers to invest more aggressively in online marketplace and carsharing applications as this industry expands.

Shifting to connecting people to vehicles: We believe the regulatory scrutiny over gig-economy workers marked by bills such as AB 5 will likely persist, leading to nationwide upward pressure on labor costs for gig-economy ridesharing and delivery platforms. Driven by investor pressure to move toward profitability, ridesharing companies will ultimately pass along the increased cost to consumers by raising prices. We believe increased prices in ridesharing will likely push consumers toward potentially more affordable, alternative mobility tech services such as shared micromobility and carsharing—businesses not dependent on drivers. More broadly, we think this speaks to a broader trend in mobility tech—moving away from connecting people to drivers, and instead connecting people directly to vehicles.

Cities establish themselves as gatekeepers: As next-generation mobility tech businesses increasingly own and operate fleets, we believe the power of cities as important stakeholders and ultimately gatekeepers has strengthened. Mobility tech companies that run afoul of cities risk being shut down or excluded from mobility tech pilot programs. We believe successful providers will be those that can generate goodwill with city officials to win RFPs and expand services. One example of this is shared e-scooter startup **Spin** (backed by **Ford**), which provided free rides to essential workers in Detroit and Washington DC in the US, even while its competitors **Bird** and **Lime** suspended operations. Shared e-moped company **Revel** proactively shut down its service after a series of fatalities in New York and implemented additional safety protocols to prevent future incidents. Startup Ooonee partners with cities to provide e-bike charging infrastructure financed by advertisements. We believe a measured, collaborative approach to engaging with cities will be key to success as the mobility industry evolves.

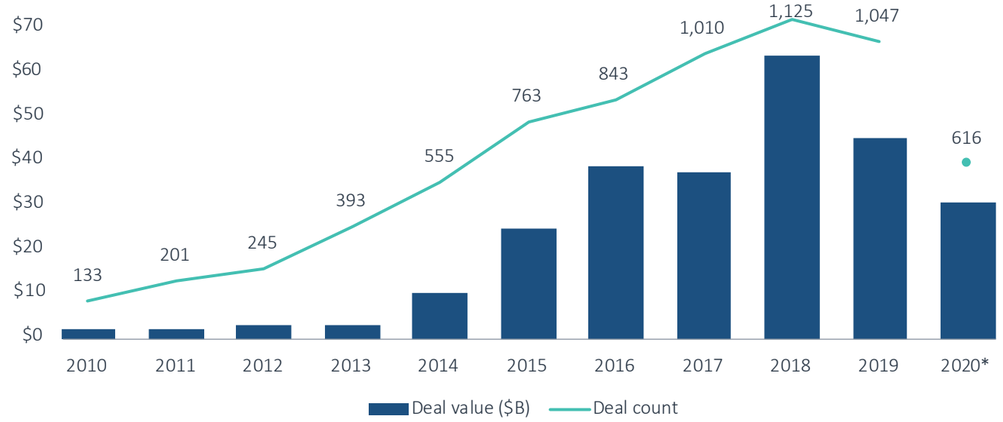
VC activity

In terms of venture activity, 2020 has been a mixed year so far for mobility tech companies. Aggregate funding remains strong despite the current downturn as investors continue to deploy large sums of capital into late-stage mobility tech companies. Deal value in 2020 is on pace to rival 2019's total, sitting at $28.0 billion as of Q3, compared to $41.2 billion invested in all of 2019. However, deal count is on pace to fall below last year's total of 1,047, with 616 deals completed so far this year.

The industry is currently experiencing a major divergence in valuations. Although funding toward late-stage mobility tech companies remains strong, early-stage mobility companies are seeing significant pressure as investors pull back on deals, leading to a decline in valuations. As of Q3 2020, the median pre-money valuation for angel & seed and early-stage mobility tech companies declined 20.0% and 37.8% YoY respectively. Meanwhile, the median pre-money valuation for late-stage mobility tech companies increased 46.6% YoY to $249.2 million.

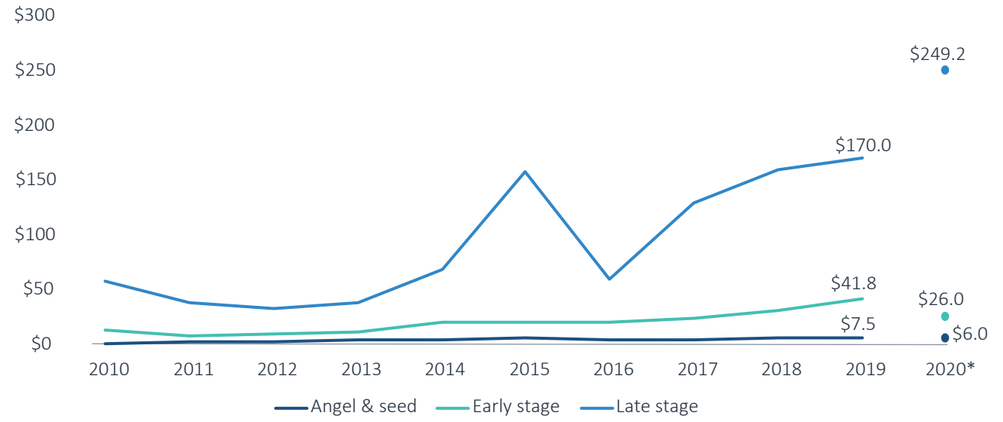
We believe declining deal counts and diverging valuations are the result of investors prioritizing investments in "winners," which tend to be late-stage companies. As this dynamic continues, we believe early-stage companies are facing a more challenging fundraising environment. On the other hand, we believe it is an opportune time for discerning financial and strategic investors with dry powder to acquire or invest in technology and talent in the space at discount valuations.

Figure 1. MOBILITY TECH VC DEAL ACTIVITY



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 2. MEDIAN MOBILITY TECH VC PRE-MONEY VALUATION ($M) BY STAGE



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 3.

Top 15 mobility tech VC mega-deals in Q3 2020

COMPANY NAME	CLOSE DATE	SUBSEGMENT	DEAL SIZE ($M)	POST-MONEY VALUATION ($M)*	STAGE	LEAD INVESTOR(S)
Weltmeister	September 9, 2020	Electric vehicle platforms	$1,470.0	N/A	Series D	Shanghai International Group, **SAIC** Capital China
Northvolt	September 29, 2020	Electric vehicle charging, battery & motor tech	$600.0	N/A	Early-stage VC	Goldman Sachs Merchant Banking Division, **Volkswagen**, Baillie Gifford
Xpeng	July 20, 2020	Electric vehicle platforms	$500.0	N/A	Series C1	N/A
Miss Fresh	July 23, 2020	Delivery	$495.0	$3,500.0	Late-stage VC	CICC Capital
Kavak	September 1, 2020	Digital marketplaces	$397.2	$1,150.0	Early-stage VC	Greenoaks Capital Partners, SoftBank Group, DST Global
ChargePoint	August 5, 2020	Electric vehicle charging, battery & motor tech	$367.3	$1,367.3	Series H	Satif Group
Xpeng	August 3, 2020	Electric vehicle platforms	$300.0	N/A	Series C2	Alibaba Group
Rappi	September 24, 2020	Delivery	$300.0	$3,500.0	Late-stage VC	N/A
AUTO1 Group	July 30, 2020	Digital marketplaces	$291.3	N/A	Late-stage VC	Farallon Capital Management, The Baupost Group
Kymeta	August 25, 2020	V2X, connectivity & data management	$215.0	$375.0	Series B1	Doug Hutcheson, William Gates

Source: PitchBook | *As of September 30, 2020

Figure 3.

Top 15 mobility tech VC mega-deals in Q3 2020 (continued)

COMPANY NAME	CLOSE DATE	SEGMENT	DEAL SIZE ($M)	POST-MONEY VALUATION ($M)*	DEAL STAGE	LEAD INVESTOR(S)
Grab	August 3, 2020	Ridesharing platforms, delivery	$200.0	N/A	Late-stage VC	STIC Investments
Luminar	September 8, 2020	Lidar	$170.0	N/A	Late-stage VC	N/A
NewLink Group	July 10, 2020	Electric vehicle charging, battery & motor tech	$127.3	N/A	Series D	CICC Capital
Star Charge	September 24, 2020	Electric vehicle charging, battery & motor Tech	$125.1	$1,200.1	Series A	Schneider Electric China Investment, CICC Capital
Canoo	August 31, 2020	Electric vehicle platforms	$110.0	N/A	Corporate	N/A

Source: PitchBook | *As of September 30, 2020

Figure 4.

Key publicly traded OEMs

COMPANY NAME	EV/TTM REVENUE	EV/TTM EBITDA
Volkswagen	1.0x	6.8x
Daimler	1.1x	9.5x
BMW Group	1.5x	12.4x
PSA Groupe	0.2x	2.4x
General Motors	1.2x	8.5x
Ford	1.1x	N/A
Fiat Chrysler Automobiles	0.3x	4.7x
Tesla	15.9x	N/A
SAIC Motor Corporation	0.3x	6.0x
Brilliance China Automotive Holdings	11.0x	5.4x
Zhengzhou Yutong Bus Company	1.2x	17.6x
BYD Company	2.9x	22.1x
Toyota Motor	1.3x	11.2x
Honda Motor Company	0.7x	12.5x
Hyundai Motor	1.1x	16.3x
Kia Motors	0.3x	4.8x

Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 5.

Key publicly traded suppliers

COMPANY NAME	EV/TTM REVENUE	EV/TTM EBITDA
Continental	0.7x	39.4x
Valeo	0.7x	11.0x
Aptiv	2.2x	10.4x
Magna International	0.6x	15.7x
BorgWarner	1.1x	6.9x
Lear	0.5x	10.3x
Denso	0.8x	19.7x
Aisin Seiki	0.5x	8.0x
Geely Automobile Holdings	1.4x	12.3x

Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 6.

Key publicly traded transportation services

COMPANY NAME	EV/TTM REVENUE	EV/TTM EBITDA
Avis Budget Group	2.4x	6.1x
Hertz	1.7x	5.3x
Uber	4.8x	N/A
Lyft	2.1x	N/A
Grubhub	4.6x	N/A
Meituan-Dianping	12.7x	N/A

Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 7.

Key VC-backed mobility tech companies by VC raised to date

COMPANY NAME	CATEGORY	TOTAL VC RAISED ($M)
Didi Chuxing	Ridesharing platforms	$23,941.4
Uber	Ridesharing platforms, delivery	$13,688.1
Grab	Ridesharing platforms, delivery	$9,826.1
Meituan-Dianping	Delivery	$8,800.0
Gojek	Ridesharing platforms, delivery	$5,051.0
Lyft	Ridesharing platforms	$4,912.4
Weltmeister	Electric vehicle platforms	$3,915.5
Hellobike	Network operators	$3,516.9
Guazi Used Car	Digital marketplaces	$3,510.0
Ola	Ridesharing platforms, electric vehicle platforms	$3,338.7
Ele.me	Delivery	$3,335.5
Faraday Future	Electric vehicle platforms	$3,080.0
Waymo	Full stack, ridesharing platforms	$3,000.0
Xpeng	Electric vehicle platforms	$2,552.9

Source: PitchBook | Geography: Global | *As of September 30, 2020

Mobility tech VC ecosystem market map

Click to view interactive market map on the PitchBook platform

Market map is a representative overview of venture-backed or growth-stage providers in each segment. Companies listed have received venture capital or other notable private investments.

Autonomous vehicles (software)

Full stack

cruise, WAYMO, ARGO AI, nuro, Uber ATG, Aurora, pony.ai, tusimple, momenta

Perception software

RECOGNI, Zongmu, ALMCAR, PERCEPTIVE AUTOMATA, Brodmann17, helm.ai

Teleoperation

Phantom Auto, Formant, DriveU, Cambrian Intelligence, FORMATION, objective

Localization/mapping

mapbox, DYNAMIC MAP PLATFORM, swift NAVIGATION

Simulation/dev tools

Applied Intuition, cognata, foretellix, EDGE CASE RESEARCH, RENOVO, TENSYR

Autonomous vehicles (hardware)

Lidar

Velodyne Lidar, QUANERGY, LUMINAR, INNOVIZ TECHNOLOGIES, (Hesai), LeddarTech, 北科天绘 (Surestar), OUSTER, AEVA, INSIGHT LIDAR

Radar

vayyar, UHNDER, ECHODYNE, arbe, METAWAVE, OCULII

Cameras

GEO Semiconductor, Seek thermal, TRIEYE, ADASKY, Slightech, SEEVA

V2X

KYMETA, Valens, Autotalks, VENIAM, SAVARI, WORLD SENSING

Processors

Horizon Robotics 地平线机器人技术, GRAPHCORE, SambaNova SYSTEMS, TTTech, cerebras, blaize

Auto commerce

Carsharing

getaround, START, TURO, zipcar, SOCAR, CLUNO, Zoomcar Never Stop Living, 凹凸出行 (Atzuche), getaround ex drivy, 小灵狗出行 (XLG)

Digital marketplaces

瓜子二手车直卖网 Guazi.com, AUTO1 GROUP, 人人车 renrenche.com, CAZOO, KAVAK, 车置宝 (Chezhibao), 天天拍车 (Tiantian Paiche), droom, SHIFT, ACV AUCTIONS

Financing & subscriptions

fair, lendbuzz, TREND, boro, 第1车贷 chedai, tricolor auto

Repair & maintenance

途虎养车 tuhu.cn, 开思 (CassTime), 哈公里智能 (Yigongli), 典典养车 (Diandian Yangche), BOOSTER, YourMechanic, GoMechanic, 集群车宝 JIEKUN Auto, WRENCH, UVEYE

Other auto commerce

RIPCORD, carwow, CarPrice, ROADSTER, Buckle, DRIVETRIBE

Fleet management & connectivity

Fleet management

samsara, lytx, G7, CAMBRIDGE MOBILE TELEMATICS, SMARTDRIVE, Fleetmatics, UPTAKE, 图吧 www.mapbar.com, nauto

Connectivity & data management

Gigamon, Metromile, wejo, INRIX, mivision, cubic telecom, Airbiquity, JOYNEXT, otonomo, RIDECELL

Auto cybersecurity

Green Hills SOFTWARE, MOCANA, Upstream, Karamba Security, GUARDKNOX, Trillium

Passenger safety

mojo, WAYRAY, nexar, owlcam, ENVISICS, eyesight

Parking

Passport, SPOT HERO, arrive, FlashParking, REEF, akippa

Mobility tech VC ecosystem market map

Click to view interactive market map on the PitchBook platform

Market map is a representative overview of venture-backed or growth-stage providers in each segment. Companies listed have received venture capital or other notable private investments.

Micromobility

Network operators

哈啰出行 (Hellobike), Lime, Bird, gogoro, BOUNCE, voi., skip, Didi Bike, citibike provided by lyft, superpedestrian

Vehicle suppliers

ninebot, ATHER, VANMOOF, RAD POWER BIKES, HONGJI, ONEWHEEL, UNAGI, ARC, HumanForest

Management & analytics platforms

Ride Report, POPULUS, ZOBA, Joyride

Positioning

NAVMATIC, Fantasmo

Ridesharing

Ridesharing platforms

DiDi, Grab, gojek, OLA, Gett, Via, cabify, BlaBlaCar

Augmented interior

FIREFLY, CARGO, octopus, Wrapify, VUGO Rideshare Advertising, HALO

Demand planning

PredictHQ, Gridwise, Everlance, (Empower), SherpaShare, mystro

Last-mile delivery

Last-mile delivery

DOORDASH, instacart, (Miss Fresh), Rappi, SWIGGY FOOD DELIVERY APP, deliveroo, goPuff, zomato, (Xingsheng Selected), JUST EAT

Electric vehicles

Electric vehicle charging, battery & motor tech

northvolt, QuantumScape, chargepoint, SQM, Литех, microvast, 能链集团 NEWLINK GROUP, SILA NANOTECHNOLOGIES, Trojan BATTERY COMPANY

Electric vehicle platforms

SAIC 上汽集团 SAIC MOTOR, RIVIAN, Faraday Future, WELTMEISTER 威马汽车, BAIC BJEV 北汽新能源, YOUXIA MOTORS, BYTON, SINGULATO 奇点汽车, LUCID, CANOO

Urban air mobility

Unmanned aerial vehicles

zipline, 3DR, Skydio, dji, PRECISION HAWK, AIROBOTICS, SKYCATCH, DroneDeploy, SAILDRONE, Makeblock

Air taxis

JOBY AVIATION, LILIUM, VOLOCOPTER, KITTYHAWK, EVIATION, DAEDALEAN, Skyryse, SKYDRIVE, NITA INCLINATA, XTI AIRCRAFT

SEGMENT DEEP DIVE

Autonomous vehicles

Overview

Autonomous vehicle technology refers to software and hardware solutions that enable self-driving or driver assistance capabilities for cars, trucks, and other on-road vehicles. Subsectors in this category include:

Full-stack solutions: Platforms and solutions that provide full-turnkey self-driving or driver-assistance capabilities. These include:

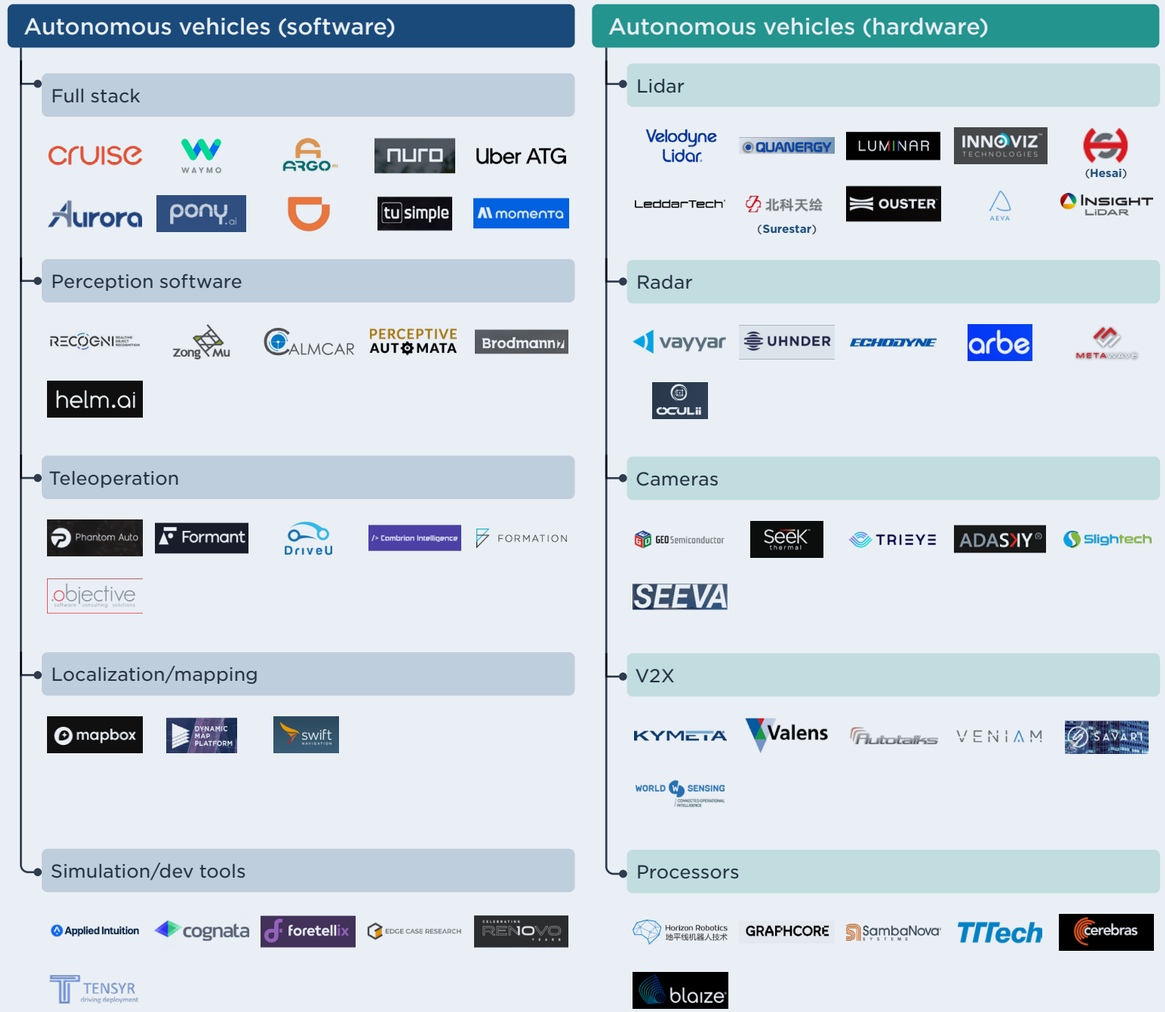
- Self-driving vehicles
- Self-driving platforms for retrofitting

Autonomous software: Software tools that enable self-driving capabilities. Technologies in this subsegment include:

- Perception
- Localization & mapping
- Teleoperation
- Simulation

Autonomous hardware: Sensors and other hardware that enable self-driving capabilities. Technologies in this subsegment include:

- Light detection and ranging (lidar)
- Radar
- Cameras



Industry drivers

Reducing transportation costs: Autonomous vehicles have the potential to significantly lower the cost of transporting people and goods. Driving as an activity is time-consuming and drains productivity. In the US, the mean commute time between 2014 and 2018 totaled over 200 hours every year.[1] According to McKinsey, traffic congestion has a negative impact of 2%-5% on GDP due to wasted time, fuel, and additional friction.[2]

Improving transportation safety: Autonomous vehicles present many potential benefits over traditional driving in both economic efficiency and safety. Human-caused car accidents result in approximately 40,000 deaths annually in the US.[3] Autonomous vehicles could solve many of these issues by routing traffic more efficiently and markedly reducing the potential for human error.

A race among automakers and technology companies to dominate a burgeoning industry: Automakers and technology companies are investing heavily in autonomous technology and fueling innovation in the space. In July 2019, **Cruise** Automation—a subsidiary of **General Motors** (GM)—received $3.4 billion of development capital from SoftBank and GM. In July 2018, **Ford** committed $4.0 billion to autonomous vehicle development, and **Volkswagen** has committed $2.6 billion into **Argo AI**, which **Ford** acquired for $1.0 billion in 2017. In 2018, Intel acquired **Mobileye** for $14.9 billion, representing the largest corporate acquisition in the space so far. Finally, **Waymo**—a subsidiary of Alphabet—received $3.0 billion in a late-stage VC round in May 2020, pushing the company's post-money valuation to $30.8 billion.

1: "2014-2018 American Community Survey 5-Year Estimates," U.S. Census Bureau, 2018
2: "Mobility's Second Greatest Inflection Point," McKinsey Quarterly, Rajat Dhawan, Russell Hensley, Asutosh Padhi, and Andreas Tschiesner, February 23, 2019
3: "National Vital Statistics Reports, Volume 68, Number 9," National Center for Health Statistics, Kenneth D. Kochanek, Sherry L. Murphy, Jiaquan Xu, and Elizabeth Arias, June 24, 2019

Market size

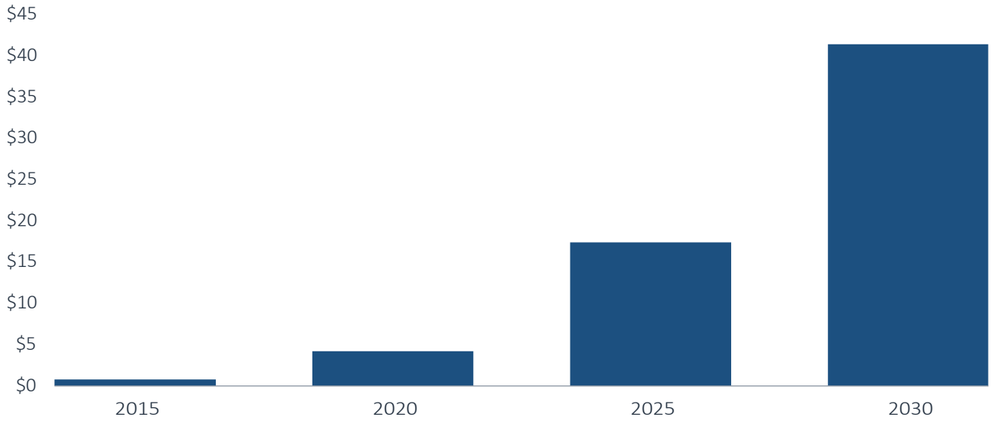
We forecast the autonomous vehicle industry to grow to $41.4 billion by 2030 through sales of global autonomous vehicle software, sensors, and other hardware revenue. This market estimate implies unit sales of approximately 600,000 autonomous and semi-autonomous vehicle platforms in 2025, rising to 8 million units sold in 2030. This estimate also suggests significant price compression of hardware units as automotive sensor and processor manufacturing costs rapidly decline. We expect the coronavirus crisis to moderately affect corporate spending in 2020, but we believe the sector remains well positioned for long-term growth.

Business model

Software providers build full-stack autonomous solutions or develop localization, mapping, perception, teleoperation, and simulation tools. Hardware suppliers manufacture sensors and equipment, such as lidar, cameras, radar, computer chips, and V2X communications solutions.

Providers in this space monetize by selling or licensing their solutions to technology companies, automakers, and automotive suppliers. In the future, full-turnkey solution providers could monetize by operating cost-effective ridesharing or delivery platforms or by selling vehicles directly to consumers and fleet operators.

Figure 8. AUTONOMOUS VEHICLES MARKET SIZE ($B)



Source: Internal PitchBook estimates | Geography: Global

Figure 9. COMMON INDUSTRY KPIS

Platform KPIs

- Total miles driven
- Miles per safety critical event
- Simulated miles driven
- Ride quality
- Autonomous fleet size
- Total AV patents

Sensor KPIs

- Range
- Resolution/ sensitivity/frame rate
- Field of view
- Unit cost
- Reliability
- Power consumption

Business KPIs

- Number of partnerships with OEMs and Tier-1s
- Yield and warranty claim rate
- Bookings growth, net revenue growth and gross margin
- Production capacity

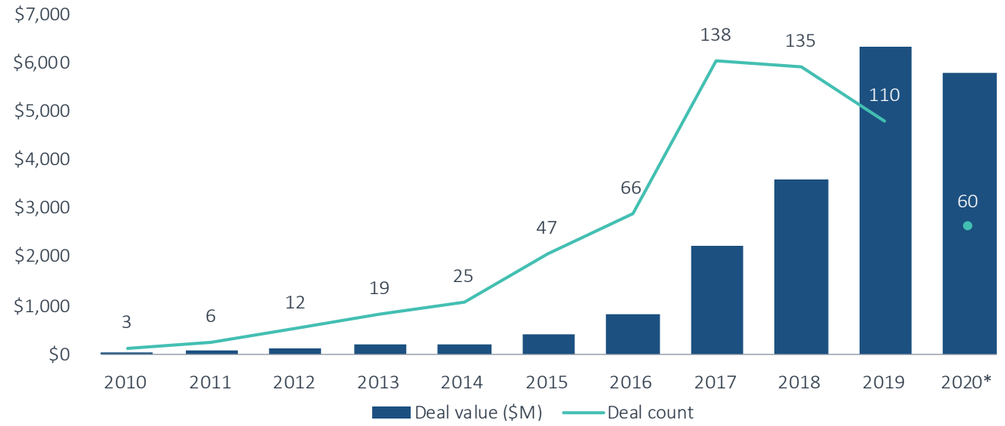
VC activity

In Q3 2020, venture investment into autonomous vehicles totaled $673.1 million, down 82.1% from Q2 2020 and down 43.9% from Q3 2019. Although Q3's deal value has not matched totals in previous quarters, the full year remains on track to hit a record high this year, with $5.8 billion invested in the first three quarters. Notable VC deals in Q3 include **Kymeta**'s $215.0 million Series B1 in August, **Luminar**'s $170.0 million late-stage VC deal in September, and Semidrive's $73.3 million Series A in September.

Corporate investment from automakers propelled some of the largest deals in the space. In 2019, **Cruise** Automation received over $4.0 billion in development capital from SoftBank, **Honda**, and GM. **Ford** has committed $4.0 billion to autonomous vehicle development, and **Volkswagen** has committed $2.6 billion into **Ford**-owned **Argo AI**. In 2018, Intel acquired **Mobileye** for $14.9 billion, marking the largest corporate acquisition in the space so far. Finally, Amazon acquired **Zoox** for $1.3 billion in the summer of 2020, becoming the company's largest bet in the space thus far.

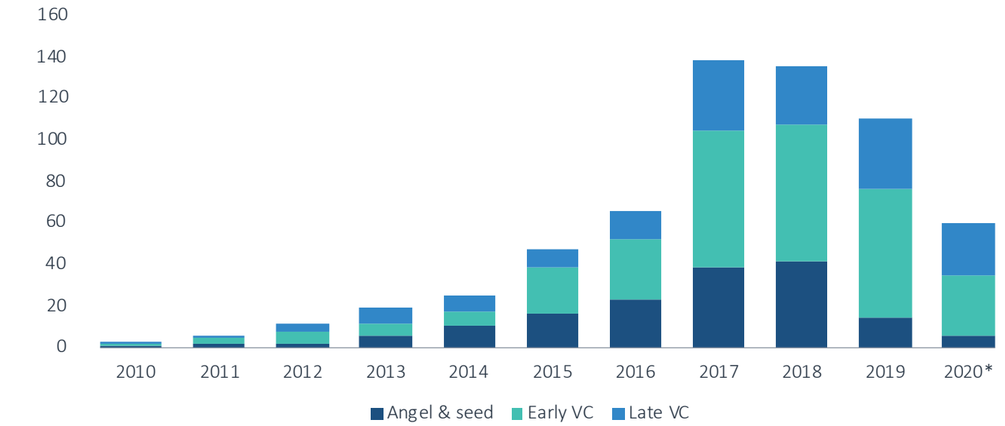
Historically, a significant portion of VC investment has gone toward startups developing full-stack autonomous solutions, such as **Pony**.AI, **Nuro**, and **Aurora**. This dynamic is changing as investors concentrate more capital in companies focused on single aspects of autonomy, such as perception or localization, or that otherwise augment the industry.

Figure 10. AUTONOMOUS VEHICLES VC DEAL ACTIVITY



Source: PitchBook | Geography: Global | *As of September 30, 2020

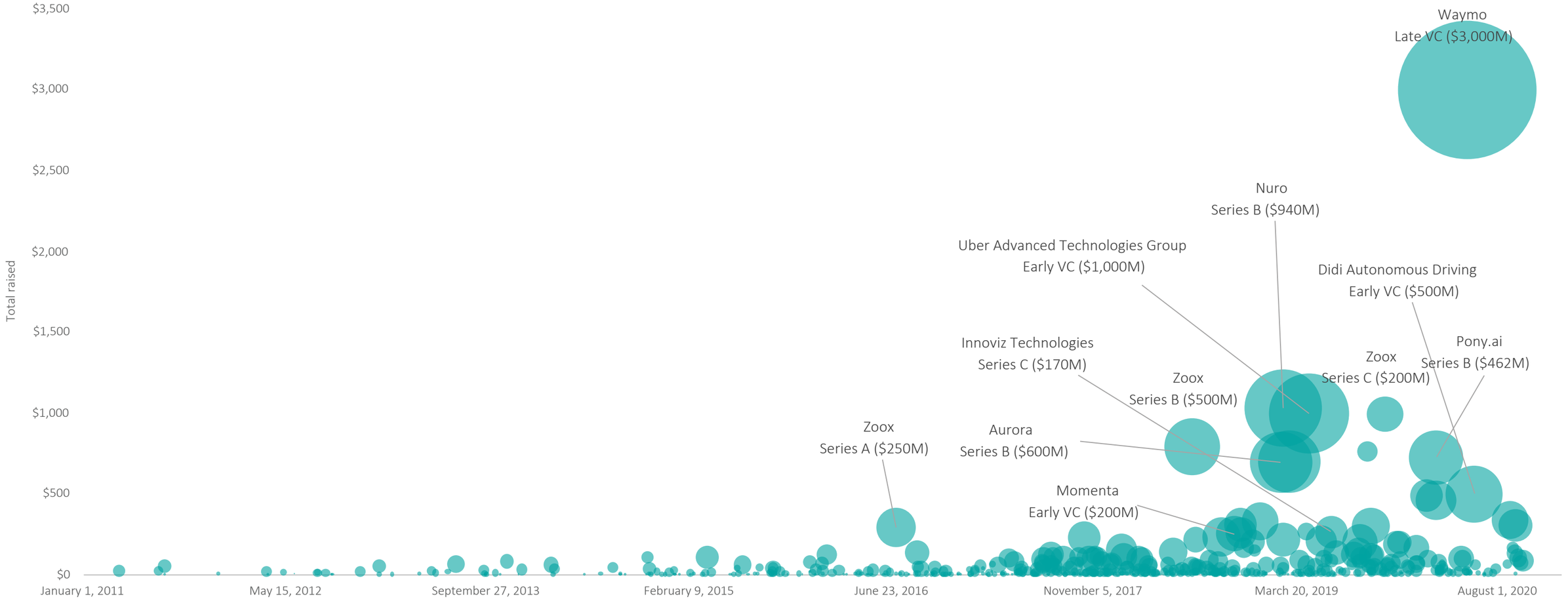
Figure 11. AUTONOMOUS VEHICLES VC DEALS (#) BY STAGE



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 12.

Autonomous vehicles VC landscape ($M)



Source: PitchBook | Geography: Global | *As of September 30, 2020

Note: The left axis indicates total VC raised as of deal date. Bubbles indicate amount raised.

AUTONOMOUS VEHICLES

Figure 13.

Notable autonomous vehicles VC deals

COMPANY NAME	CLOSE DATE	SUBSEGMENT	DEAL SIZE ($M)	POST-MONEY VALUATION ($M)*	DEAL STAGE	LEAD INVESTOR(S)
Kymeta	August 25, 2020	V2X, connectivity & data management	$215.0	$375.0	Series B1	Doug Hutcheson, William Gates
Luminar	September 8, 2020	Lidar	$170.0	N/A	Late-stage VC	N/A
Semidrive	September 28, 2020	Processors	$73.3	$484.9	Series A	CTC Capital Partners
Seegrid	September 15, 2020	Full stack	$52.0	N/A	Series B	G2VP
Ouster	September 8, 2020	Lidar, cameras	$42.0	$72.2	Series B	N/A

Source: PitchBook | *As of September 30, 2020

Figure 14.

Notable autonomous vehicles VC exits

COMPANY NAME	CLOSE DATE	SUBSEGMENT	EXIT SIZE ($M)	POST-MONEY VALUATION ($M)*	EXIT TYPE	ACQUIRER(S)/INDEX
Cambricon Technologies	July 20, 2020	Processors	$3,290.8	$3,657.4	IPO	N/A
Zoox	June 28, 2020	Full stack, ridesharing platforms, electric vehicle platforms	$1,300.0	$1,300.0	M&A	Amazon.com
Vayavision	July 7, 2020	Perception software	N/A	N/A	M&A	LeddarTech
Artisense	February 14, 2020	Lidar	N/A	N/A	M&A	Kudan
Marble Robot	June 17, 2020	Logistics	N/A	N/A	M&A	Caterpillar

Source: PitchBook | *As of September 30, 2020

Figure 15.

Key corporate-backed or acquired autonomous vehicle companies

COMPANY NAME	OWNER	SUBSEGMENT
Waymo	Alphabet	Full stack, ridesharing platforms
Zoox	Amazon	Full stack, ridesharing platforms, electric vehicle platforms
Cruise	General Motors, Honda, SoftBank	Full stack, ridesharing platforms
Argo AI	Ford, Volkswagen	Full stack, ridesharing platforms
Mobileye	Intel	Full stack
Uber Advanced Technologies Group	Uber, Toyota, SoftBank	Full stack, ridesharing platforms
Apollo	Baidu	Full stack, ridesharing platforms
Motional	Hyndai, Aptiv	Full stack

Source: PitchBook

Figure 16.

Key VC- and PE-backed autonomous vehicle companies

COMPANY NAME	TOTAL VC RAISED ($M)*	SUBSEGMENT
Nuro	$1,032.0	Full stack, delivery
Aurora (Automotive)	$762.6	Full stack, lidar
Pony.ai	$726.0	Full stack
Luminar	$306.0	Lidar
TuSimple	$297.9	Full stack, freight
Innoviz Technologies	$264.0	Lidar
Mapbox	$226.6	Localization/mapping
PlusAI	$200.0	Full stack, freight
Vayyar	$188.0	Radar
Tier IV	$166.0	Full stack
Hesai	$165.6	Lidar
Valens	$164.0	V2X, connectivity & data management

Source: PitchBook | *As of September 30, 2020

Opportunities

Highway autonomy: We expect more demand for driver assistance and autonomous technologies for highway applications over the next three to five years. Leading advanced driver-assistance systems (ADAS) on the market today, such as **Tesla**'s Autopilot and Cadillac's **Super Cruise**, provide features including adaptive cruise control, lane-keeping assist and an automatic lane-changing. Lidar startup **Luminar** has partnered with Volvo to deliver hands-free highway driving beginning in 2022. We expect more partnerships between automakers and leading startups to emerge as automakers invest in additional features to improve the safety of their vehicles.

Long-term automated ridesharing opportunity: While consumer cars will continue to incorporate autonomous features, on-demand ridesharing is likely to be a major consumer application of the technology in the long term. We anticipate scale efficiencies will primarily drive this dynamic, as the high cost of deploying autonomous vehicle technology is more economical when spread across ridesharing fleets with high utilization rates, as opposed to when purchased for personal use. Assuming the per-unit costs of autonomous vehicle technology continue to trend downward over time, on-demand applications such as ridesharing may result in much higher-margin operations. Scaling quickly and aggressively expanding service could allow leading autonomous vehicle providers to create strong ridesharing networks with rational pricing structures that undercut non-autonomous mobility solutions and provide real value to consumers. **Uber** has recently invested heavily in autonomous technology through its Advanced Technology Division, while **Lyft** has partnerships with **Waymo** and **Aptiv** to bring autonomous vehicles onto its network. Meanwhile, **Waymo** continues to test its own ridesharing service (**Waymo** One), while Amazon has signaled its ridesharing ambitions through its acquisition of robotaxi startup **Zoox**. We anticipate the mass adoption of automated ridesharing services to occur in the late-2020s or early-2030s timeframe.

"Middle-mile" and long-haul logistics: The middle-mile transport opportunity refers to the use of autonomous vehicles for the movement of goods among warehouses and shipping facilities in urban and rural locations. Unlike consumer transport, moving commercial goods is not beholden to customer expectations about passenger experience, has lower safety hurdles, and is not as sensitive to delays. These factors combine to make it a prime candidate for autonomous vehicles. Moreover, middle-mile routes are often fixed, reducing the complexity relative to dynamic passenger routing. Routes may also be in closed-off locations away from the public, such as on shipyards or docks, where collision risks are lower. These environments enable lower success thresholds relative to consumer applications, increasing time to value. Autonomous long-haul trucking also represents an attractive opportunity given the relative simplicity of automating highway driving as opposed to urban driving, as well as ongoing wage pressure and driver shortages in the trucking industry. Walmart is reportedly working to automate its logistics network through a partnership with startup **Gatik AI**. Volvo is also targeting this market with its new cab-less, fully autonomous Vera truck, for which it recently announced a partnership with Nvidia. Key VC-backed companies in the long-haul trucking space include **TuSimple**, **Embark**, and **Kodiak Robotics**. These businesses compete with more established technology companies and automakers such as **Waymo**, Volvo, and **Daimler**.

Last-mile delivery: Prior to this crisis, investors and management teams primarily viewed autonomous delivery as a means to reduce delivery costs. The pandemic has revealed

a new use case: increasing safety for consumers and helping providers ensure service continuity when human drivers can't be used. Startups exposed to this trend include autonomous robot providers **Nuro**, **Starship**, and **Refraction AI**; automated delivery van providers **Gatik**.AI and **Arrival**; and drone companies such as **Zipline**, **Flytrex**, and **Flirtey**. Autonomous delivery pilots that are underway include the partnership between CVS and **Nuro** for prescription deliveries in Houston, Texas in the US. CVS has also partnered with UPS Flight Forward, a drone-focused subsidiary of UPS working with drone startup **Matternet** to deliver medical supplies to retirement communities in Florida in the US. **Zipline** has begun leveraging its drone delivery technology, previously used in Africa, to provide personal protective equipment and essential medical supplies to US hospitals.

Lidar: Lidar enables vehicles to sense environments, process information, and ultimately make decisions. We believe lidar technology will be critical for automotive-grade, self-driving applications because it provides distance, speed, and depth information in a computationally compact fashion. Lidar technology sends out pulses or waves of laser light that hit objects and reflect to sensors on the vehicle. This effectively measures depth and is used to create high-fidelity 3D representations of the surrounding environment. Although lidar has some industrial applications, most VC investment in the last few years has gone to startups targeting the autonomous vehicle market, for which lidar technology is particularly well suited. Key companies innovating in the lidar space include **Velodyne**, **Waymo**, **Quanergy**, **Surestar**, **Luminar**, **LeddarTech**, **Innoviz Technologies**, **Ouster**, **Trilumina**, **AEye**, **Aeva**, **Robosense**, **Innovusion**, **Sense Photonics**, and **Insight Photonic Solutions**.

We believe the lidar industry is shifting away from traditional spinning applications and toward solid-state applications with fewer moving parts. While spinning lidar has set the industry standard for performance, it can be bulky and raises concerns about longevity as automobiles are constantly subject to fluctuations in temperature, vibration, and weather conditions. Solid-state applications tend to be smaller and are more easily integrated onto vehicle bodywork. Additionally, fewer moving parts could result in reduced costs associated with repair, replacement, and maintenance for fleet operators. For now, solid-state lidar is more expensive and the technology has not yet been fine-tuned for mass adoption. However, this may be changing as our data indicates VC investment in solid-state lidar has now eclipsed investment in spinning solutions. For more on the emerging lidar industry, see our note on the future of automotive lidar.

Perception software: Perception software companies sell sophisticated algorithms and datasets assisting in perception to customers such as **Waymo**, **Tesla**, and GM. Key providers include **DeepScale**, **Scale AI**, and **Prophesee**. **Scale AI**, which raised a $100.0 million Series C in August 2019, valuing the company at $1.0 billion, sells a service that labels large visual datasets that can categorize pedestrians, cars, and other objects to assist in training self-driving vehicles. **DeepScale**, which was acquired by **Tesla** in October 2019 for an undisclosed amount but was most recently valued at $53 million, has developed technology to enable computer vision with low power requirements.

Mapping software: Mapping software primarily includes high-resolution maps of city streets, with key providers including **HERE Global**, **Mapbox**, **DeepMap**, **Dynamic Map Platform**, **Carmera**, **Civil Maps**, and **Mapper**. Several different business models have arisen in this space. Leading self-driving companies such as **Waymo** tend to use in-house mapping, utilizing lidar-outfitted vehicles to collect data and internal teams to build comprehensive 3D maps. Third-party map providers, such as **DeepMap**, provide full-service platforms so self-driving developers can turn fleet data into HD maps. **DeepMap**

reportedly charges approximately $8,000 per mile for mapping services in the US. **Mapbox** sources data from developers through crowdsourcing platforms. In the near to midterm, we believe the core market opportunity for mapping software will arise from developing applications in asset tracking, navigation, dispatching, and route optimization. In the long term, we expect an increasing proportion of sales to shift to autonomous vehicle providers as self-driving fleets begin to scale.

Teleoperation: Teleoperation, or remote monitoring and control of vehicles, could be an important bridge between semi-autonomous and fully autonomous vehicles. Leading companies developing self-driving cars currently rely on safety operators sitting in vehicles. However, as the technology progresses and fleets expand, we expect the model will shift to a few operators remotely monitoring multiple vehicles. In situations where autonomous vehicles become stuck or confused, such as in construction zones, teleoperators should be able to take over remotely and safely guide the vehicle. Most major autonomous vehicle companies such as **Waymo**, **GM Cruise**, **nuTonomy**, **Zoox**, **Uber**, and **Nissan** are developing teleoperation capabilities. Smaller companies in the space developing turnkey teleoperation services include **Phantom Auto** (used by **Postmates**), **Scotty Labs** (acquired by **DoorDash** in August 2019), **Cambrian Intelligence**, **Objective Software**, **Formation**, and **Designated Driver**. Another startup in the space is **Tortoise**, which has developed a turnkey solution to retrofit teleoperation for e-scooters, enabling remote operators to efficiently return e-scooters to charging ports and high-demand areas. In our view, the most successful turnkey providers will be the ones that can solve challenges unique to teleoperation, such as latency, and the lack of important feedback mechanisms, such as G-forces.

Construction technology: We see a large market opportunity for autonomous robots in the construction industry, especially as the tight labor markets and restrictions on immigration drive up wages and as the costs to build continue putting pressure on the construction industry. These products could also be particularly valuable in a post-pandemic world as more organizations focus on preventing human disease transmission. Automating repetitive tasks can reduce labor costs and delays associated with difficulties in securing skilled labor onsite. Startup Scaled Robotics leverages perceptual sensors, such as lidar, normally utilized by autonomous cars to navigate and build precise maps of construction sites. **Built Robotics** and **SafeAI** develop systems to retrofit heavy mining and construction equipment with autonomous technology. **Boston Dynamics**' robots can move objects through challenging environments and provide remote monitoring.

Autonomous robots in warehouses: Rising ecommerce volumes and increased demand for faster delivery have led many enterprises to build small warehousing and fulfillment centers close to urban locations. These micro-fulfillment centers enable quicker delivery to consumers using last-mile delivery couriers. These centers typically cost more to operate (i.e., higher labor and real estate costs), creating an opportunity for robotics and automation services to reduce such costs. According to ABI Research, over 4 million commercial robots will be installed in 50,000 warehouses by 2025, up from around 4,000 robotic warehouses in 2018.[4] One example of a company exploring this opportunity is **GreyOrange**, which has developed scalable and modular robot systems that can be used to transport, store, and pick goods in warehouses. We believe the adoption of autonomous warehousing technologies will see growth over the long term as enterprises seek to reduce labor costs. **Fetch Robotics** has developed autonomous mobile robots that

4: "Robotics in E-Commerce Fulfillment," ABI Research, 2019

can find inventory in warehouses and move pieces, cases, and pallets. Private companies in the space include **Geek+**, **Boston Dynamics**, **Fetch Robotics**, **GreyOrange**, **RightHand Robotics**, **Fabric**, **TakeOff**, **6 River Systems**, **Magazino**, **IAM Robotics**, **Exotec Solutions**, **Invia Robotics**, **ATTAbotics**, **Kindred**, **Plus One Robotics**, and **Alert Innovation**.

Simulation technology could reduce barriers to entry: Simulation companies provide original equipment manufacturers (OEMs), Tier 1 suppliers, and other businesses developing self-driving cars with tools enabling the testing of autonomous vehicle software via simulators. This allows self-driving cars to rack up millions of miles and run through a multitude of scenarios without the significant time and expense inherent to doing this in the real world. We believe autonomous vehicle software simulation startups have the potential to radically disrupt barriers to entry. This should allow emerging self-driving applications to close the gap on leaders in the space more quickly than if they had to physically put cars on the road. We see significant opportunity in this space for early investors given autonomous vehicle simulation software is a fast-growing sector with strong demand tailwinds from automakers, Tier-1 suppliers, and technology companies racing to reach an autonomous solution. Key players in the space include **Cognata**, **AImotive**, **Renovo Motors**, **Applied Intuition**, **PolySync**, and **Ansys**. Some of these companies have developed simulation platforms built on top of existing game engines, while others such as **AImotive** have created their engines from the ground up.

Considerations

Competitive industry with large, well-capitalized backers: At this stage of the investment cycle, startups need billions in capital to develop a solution to compete with established leaders, and we believe new, early-stage entrants creating full-stack solutions will struggle to compete. The most successful startups are likely to be ones providing solutions to augment autonomy rather than enable it.

We view **Waymo** as a leader in terms of technological superiority and potential scalability. This is not surprising given **Waymo**'s first-mover advantage. Other competitors include GM-owned **Cruise Automation**, whose chosen test ground of busy San Francisco streets may be a key advantage; Amazon-owned **Zoox**, whose robotaxis have shown a penchant for navigating both urban and highway environments; Intel-owned **Mobileye**, which has adopted a camera-centric approach to autonomy; and **Argo AI**, which has received large financing rounds from **Ford** and **Volkswagen**. Chinese startup **Pony.AI** is also a key competitor in the space.

Automakers including **Tesla**, **Daimler**, **Volvo**, **BMW**, **Audi**, and **Toyota** are also developing autonomous solutions. In the ridesharing space, **Uber**, **Lyft**, and **Didi Chuxing** are investing in autonomous technology to supplement human drivers. Other major players include China-based technology companies **Baidu**, **Tencent**, and **Alibaba**, all of which are testing their own autonomous vehicle solutions.

Progress hindered by siloed nature of industry: We believe the closed-source approach to software development in the autonomous vehicle industry has been detrimental to progress. Despite a multitude of companies working on the same problem, autonomous vehicle development has largely been siloed with various players keeping their data in-house. For example, **Tesla** stores most of its data on vehicles and periodically sends out targeted queries for data meeting certain criteria for network training. As a result, only a small percentage of each vehicle's recordings and data collected is fully utilized. Conversely, a shared pool of billions of on-road miles could speed up development processes while key performance metrics such as miles per intervention could be better

defined and standardized. While some companies such as **Comma.ai** and Apollo are providing open-source autonomous software, this approach has not received much traction in the industry.

Commercialization stalled by machine-learning kinks: Although deep learning has enabled significant progress in autonomous driving, the technology still has its shortcomings. While deep learning is excellent at categorizing objects or scenarios it has seen, it performs less well when contextualizing objects and scenarios it hasn't categorized. For example, placing small stickers on a stop sign can sometimes cause an autonomous vehicle to fail to recognize the sign and consequently not stop.[5] Early-stage autonomous vehicle startups such as **Wayve** and **Ascent Robotics** are pursuing a deep reinforcement learning model. Whereas large technology companies train vehicles by using rules, large datasets, and sophisticated sensory equipment, **Wayve** uses limited amounts of data with a greater focus on machine learning. **Ascent Robotics** has adopted a similar approach and partnered with Microsoft to train industrial robots. These kinds of novel approaches will be key to solving issues surrounding the limitations of deep learning technology and ultimately enabling commercialization.

Commoditization of sensor technology: In the longer term, we believe price compression for lidar systems could have a negative impact on gross margins for suppliers and make it more difficult for new entrants to compete. While costs can remain high in the near term as autonomous vehicle companies undergo testing phases and are willing to spend more on new technologies, we believe downward pricing pressure is already occurring in the lidar industry. **Waymo** has reportedly lowered the cost of its in-house mid-range lidar units to just $4,000, and lidar company **Strobe** announced that it has lowered the cost of its lidar technology by 99%, after which it was acquired by **Cruise Automation**. For more on this dynamic, see our note on the future of automotive lidar.

Outlook

The next wave of SPACs to focus on autonomy: Strong public market investor enthusiasm for electrification (i.e., **Tesla**) is driving a wave of SPAC debuts on the market. Several electric vehicle startups, including **Canoo**, **Fisker** Inc, **Karma Automotive**, **Lordstown Motors**, Nikola Motors, and **Faraday Future**, have announced plans to debut on public markets, many through SPACs. Similar to electric vehicle startups, autonomous vehicle startups are typically pre-revenue (or early revenue), highly capital intensive, and have strong secular tailwinds driving long-term adoption. We believe **Velodyne**'s public debut through a SPAC reverse merger has already validated this pathway to public markets for lidar companies, with **Luminar** following suit in its upcoming reverse merger with Gores Metropoulis. Leading lidar suppliers that could seek to go public via a SPAC reverse merger include Innoviz, **AEye**, and **Ouster**. Full-stack autonomous vehicle startups such as **Aurora** Innovation and **Nuro** could also capitalize on burgeoning investor enthusiasm in next-generation autonomous mobility technology.

Tech companies pulling ahead in the race to self-driving: Well-financed tech companies are poised to take share of the self-driving vehicle market, to the detriment of incumbent automakers. Many automakers are facing pandemic-induced financial pressure and have been forced to focus inward on their core businesses, leading to delayed projects and

5: "Robust Physical-World Attacks on Deep Learning Models," Kevin Eykholt, et. al., July 27, 2017

curtailed investments in long-term bets such as self-driving technology. Additionally, incumbent automakers face the daunting task of electrifying their fleets to meet increasingly stringent emissions standards while fending off a new wave of electric vehicle startups.

M&A on the cards: We expect additional consolidation to occur in the self-driving industry, as capital needs increase and the need to eliminate silos among projects becomes more evident. The autonomous vehicle industry is currently fragmented, with hundreds of different companies and projects concurrently working on similar projects. As we have noted, this fragmentation has led to hindered progress in technological development as the various players keep their data in-house. Industry partnerships and ultimately M&A will be key to removing silos in the industry. Additionally, the high capital intensity of developing autonomous technology, which is typically four to five times that of other verticals, will necessitate consolidation; only a few companies have the balance sheets necessary to finance long-term investment. The industry has already seen an uptick in recent M&A and partnerships, including **Uber**'s partnership with **Toyota**, Fiat Chrysler's partnership with **Aurora**, **Volkswagen**'s partnership with **Ford**, **Hyundai**'s partnership with **Canoo**, Apple's acquisition of **Drive.ai**, **Daimler**'s partnership with **BMW**, **Lyft**'s partnership with **Waymo**, **Hyundai**'s partnership with **Aptiv**, Volvo's partnership with **Waymo**, and Amazon's acquisition of **Zoox**. We expect continued partnerships and acquisitions to occur and view VC-backed **Aurora** Innovation and **Nuro** as attractive acquisition targets.

Partnerships will be critical to success for sensor suppliers: As product cycles for automobiles can extend well over 10 years, long-term partnerships with leading automakers and Tier-1 suppliers will provide significant competitive advantages. Automakers have strict requirements for performance, reliability, and longevity, and companies meeting those requirements stand to succeed in the space. Companies such as **Luminar**, **AEye**, **Hesai**, and **Velodyne** have shown success at establishing partnerships with key OEMs and suppliers.

Autonomous use cases in structured environments to emerge first: Autonomous technology deployment is likely to emerge first in structured use-case environments, with fewer variables such as human-driven cars and pedestrians, before gradually expanding to unstructured environments with greater ambiguity and safety considerations.

We anticipate off-road and highway (Level 2-3) applications of autonomy to arrive in the mid-2020s.Startups focused on warehouse, dockyard, airport logistics, mining, and construction may be the first to see widespread adoption. **Built Robotics**, **SafeAI**, and Aerovect are retrofitting heavy trucks and equipment with autonomous technology. During this same period, we anticipate leading automakers such as **Tesla** and Volvo/ **Luminar** to roll out limited autonomous driving for highways on passenger vehicles. Additionally, we expect leading self-driving trucking companies such as **TuSimple**, **Embark**, and **PlusAI** to begin automation of long-haul Class 8 trucks.

In the late 2020s to early 2030s, we expect robotaxis (Level 4-5 autonomy) to be widespread in major cities and available through ridehailing applications. These vehicles will be able to navigate complex urban, suburban, and rural environments without the need for a safety driver. In limited circumstances, teleoperators may be required to take control during unforeseen situations.

Early-stage startups will pivot to logistics: As VC-backed startups face increasing pressure to commercialize, we believe many will pivot toward logistics, where nearer term revenue opportunities may exist. Many autonomous vehicle software technologies, such

as teleoperation, simulation, and mapping, are well suited to solving issues in last-mile delivery, long-haul freight, and industrial robotics. Teleoperation providers such as **Scotty Labs** and **Phantom Auto** are already deploying technology with delivery bots, while autonomous robot companies **Scaled Robotics** and **Built Robotics** are finding success in construction-related applications.

Startups will pursue exits at discounts to previous valuations: Financial pressure from the coronavirus pandemic could create attractive buying opportunities for technology companies. As startups undergo financial duress and seek capital infusions, acquisitions may represent the best exit opportunity, especially for startups lacking cash to invest in alternative business models. Recent deals that we believe were completed at discounts include **DoorDash**'s acquisition of **Scotty Labs** in August 2019, the latter of which reportedly had difficulty raising capital after losing a major customer. In June 2019, Apple acquired **Drive.ai** for $77 million, significantly lower than the $200 million valuation the startup had in mid-2017. Most notably, Amazon acquired struggling robotaxi startup **Zoox** for $1.3 billion, a significant revaluation from the company's last valuation of $3.2 billion.

Figure 17.

Last known autonomous vehicle company post-money valuations

SELF-DRIVING CARS		
WAYMO	$30.8B	March 2, 2020
cruise	$19.0B	May 7, 2019
MOBILEYE An Intel Company	$14.9B	April 1, 2018
Uber ATG	$7.3B	April 18, 2019
ARGO AI	$7.3B	July 12, 2019

SELF-DRIVING TRUCKS		
tusimple	$1.2B	September 17, 2019
plus.ai	$1.0B	August 21, 2019
EMBARK	$520.0M	September 25, 2019
Ike	$250.0M	February 5, 2019
Kodiak	$210.0M	August 7, 2018

Source: PitchBook | Geography: Global | *Internal estimates

*Note: **Waymo** is also reportedly testing its technology on long-haul trucks.*

SEGMENT DEEP DIVE

Ridesharing

Overview

Ridesharing consists of hailing a private vehicle or a taxi via a mobile app or platform for a shared or individual ride. The industry began with the launch of **Uber** in the US 10 years ago and has since expanded into a multibillion-dollar global business. Ridesharing has achieved widespread adoption as it solves the cost and convenience issues of incumbent transportation services. Subsegments in ridesharing include:

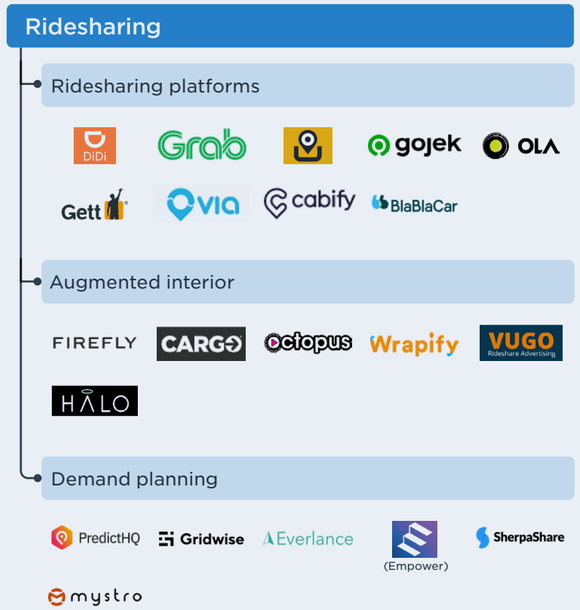
Ridesharing platforms: Applications enabling consumers to hail a private vehicle for a shared or individual ride. These include:

- Private rides
- Luxury rides
- Shared rides

Augmented interior & exterior: Technologies and services meant to augment the passenger riding experience. These include:

- Interior and exterior screens and media entertainment
- Snack and consumer product vendors

Demand planning: Applications that help drivers and riders optimize earnings and compare costs.



Industry drivers

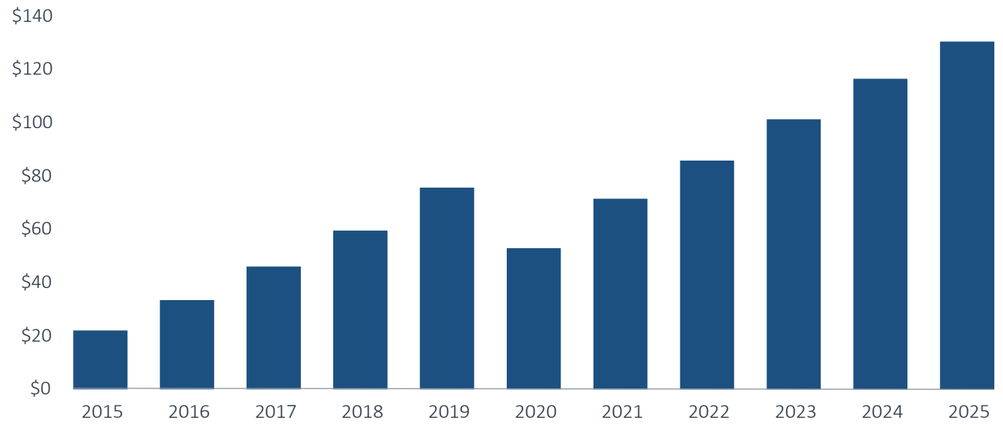
Lower price and convenience relative to traditional taxi and car services: Ridesharing companies can provide rides at lower costs relative to traditional taxi and car services. This is because they are primarily software companies that connect riders, drivers, and vehicles and can avoid much of the employment and vehicle maintenance costs common to traditional providers. Leading platforms can also provide more convenient app-based services that utilize a broad network of drivers to ensure prompt on-demand pickup times. Consumers are also attracted to the price transparency and seamless payment features offered by many providers.

Large customer network enables expansion into new markets and services: Industry leaders such as **Uber**, **Lyft**, **Didi Chuxing**, and **Grab** provide a diversified range of offerings including micromobility, public transportation booking, and other ancillary services. For example, **Lyft** now operates the largest bikesharing service in the US and has a section of its app dedicated to finding public transportation options in select cities. **Uber** has also expanded into food delivery, micromobility, and freight brokerage. These diversified platforms could prove more defensive in the current downturn.

Market size

Global net revenue from ridesharing reached approximately $75.8 billion in 2019, and we forecast this to grow to $130.6 billion by 2025, implying a CAGR of approximately 15%. We expect consumer adoption among developing countries to be one of the key drivers of increased growth in the industry. We also anticipate a significant pullback in 2020 as a result of the coronavirus crisis but believe spending will recover to pre-coronavirus levels by 2022.

Figure 18 RIDESHARING MARKET SIZE ($M)



Source: Orbis Rsearch, internal PitchBook estimates | Geography: Global

Figure 19. COMMON INDUSTRY KPIS

- Monthly active platform consumers (MAPC)
- Take rate % (net revenue/gross bookings)
- Contribution margin
- Customer acquisition cost (CAC)
- Size of driver network
- Average wait times
- Price per mile
- App downloads

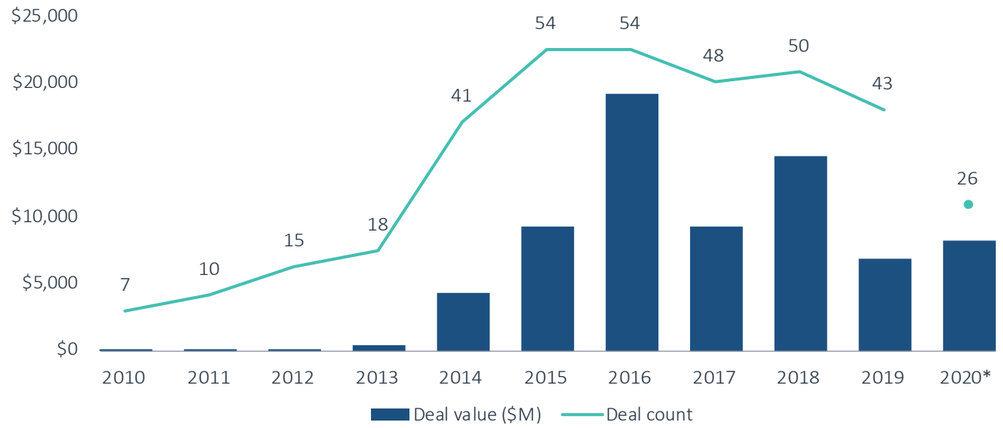
Business model

Businesses in this category create digital platforms to connect people with drivers. Ridesharing companies monetize by charging users one-time or subscription-based fares, a portion of which is distributed to operators or vehicle owners.

VC activity

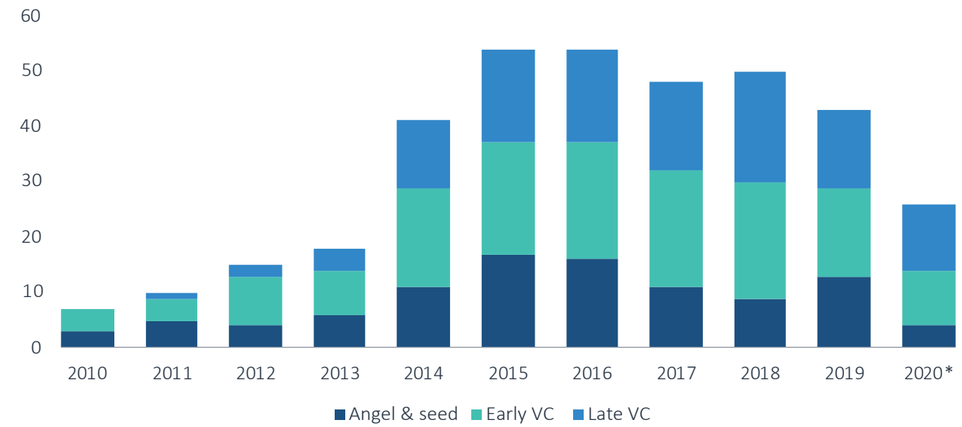
Headwinds associated with the coronavirus pandemic appear to be weighing on funding for the ridesharing sector. Companies in this sector raised $344.5 million in funding in Q3 2020, down significantly from the $3.6 billion raised in Q2 2020. Top deals in the quarter include **Grab**'s $200.0 million late-stage VC round in August and **Gett**'s $100.0 million late-stage VC round in July. Nevertheless, aggregate funding for ridesharing startups has been relatively strong for the year, with $8.7 billion invested in the first three quarters of 2020. Mirroring trends for the broader mobility space, the majority of capital invested into ridesharing startups has gone toward late--stage companies. Outsized deals in Q2 include **Bolt**'s $108.9 million late-stage VC round, valuing the company at $1.9 billion, and **Splyt Technologies**' $19.5 million Series B led by SoftBank. Going forward, we expect continued VC investment to focus largely on international late-stage ridesharing competitors such as **Grab**, **Didi Chuxing**, and **Ola**.

Figure 20. RIDESHARING VC DEAL ACTIVITY



Source: PitchBook | Geography: Global | *As of September 30, 2020

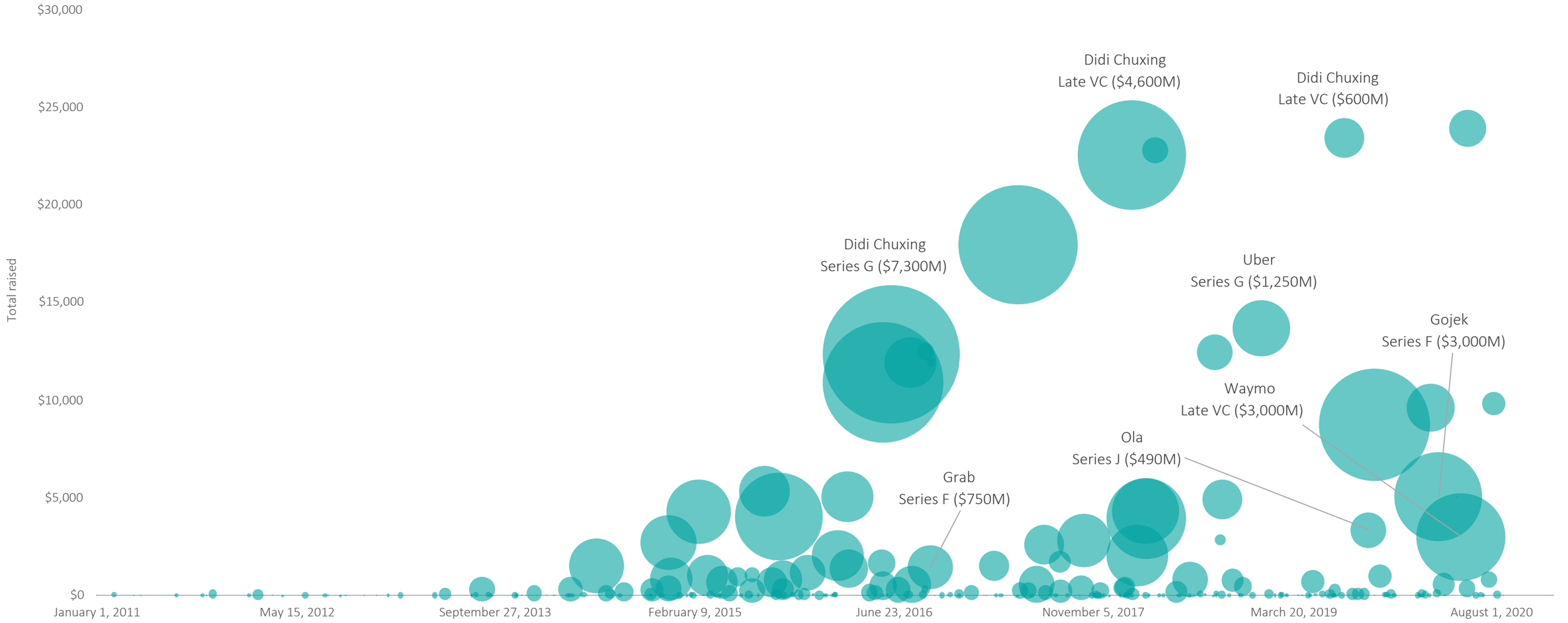
Figure 21. RIDESHARING VC DEALS (#) BY STAGE



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 22.

Ridesharing VC landscape ($M)



Source: PitchBook

Note: The left axis indicates total VC raised as of deal date. Bubbles indicate amount raised.

RIDESHARING

Figure 23.

Notable ridesharing VC deals

COMPANY NAME	CLOSE DATE	SUBSEGMENT	DEAL SIZE ($M)	POST-MONEY VALUATION ($M)*	DEAL STAGE	LEAD INVESTOR(S)
Grab	August 3, 2020	Ridesharing platforms, delivery	$200.0	N/A	Late-stage VC	STIC Investments
Gett	July 21, 2020	Ridesharing platforms	$100.0	N/A	Late-stage VC	N/A
Airlift Technologies	July 1, 2020	Ridesharing platforms	$10.0	N/A	Series A1	Quiet Capital
Picap	July 8, 2020	Ridesharing platforms	$4.5	N/A	Early-stage VC	N/A
Empower	August 26, 2020	Demand planning	$2.3	N/A	Angel	N/A

Source: PitchBook | *As of September 30, 2020

Figure 24.

Notable ridesharing VC exits

COMPANY NAME	CLOSE DATE	SUBSEGMENT	EXIT SIZE ($M)	POST-MONEY VALUATION ($M)*	EXIT TYPE	ACQUIRER(S)/INDEX
Careem	January 2, 2020	Ridesharing platforms	$3,100.0	$3,100.0	M&A	Uber
itaxi	August 21, 2020	Ridesharing platforms	N/A	N/A	M&A	Citylink (Automotive)
Uber	May 10, 2019	Ridesharing platforms, delivery	$67,613.5	$75,713.5	IPO	New York Stock Exchange
Lyft	March 29, 2019	Ridesharing platforms	$21,660.0	$24,000.0	IPO	NASDAQ

Source: PitchBook | *As of September 30, 2020

RIDESHARING

Figure 25.

Key VC- and PE-backed ridesharing companies

COMPANY NAME	TOTAL VC RAISED ($M)	SUBSEGMENT
Didi Chuxing	$23,941.4	Ridesharing platforms
Grab	$9,826.1	Ridesharing platforms, delivery
Gojek	$5,051.0	Ridesharing platforms, delivery
Ola	$3,338.7	Ridesharing platforms, electric vehicle platforms
UCAR Technology	$1,656.5	Ridesharing platforms
Gett	$793.0	Ridesharing platforms
Via (Social/Platform Software)	$586.9	Ridesharing platforms, smart transit
BlaBlaCar	$466.6	Ridesharing platforms
Cabify	$405.9	Ridesharing platforms
Bolt (Tallinn)	$362.8	Ridesharing platforms
HopSkipDrive	$97.7	Ridesharing platforms
Swvl	$92.5	Ridesharing platforms, smart transit

Source: PitchBook | *As of September 30, 2020

Opportunities

Emerging markets: With **Uber** and **Lyft** dominating the US market, more opportunity may exist in emerging markets. Local operators have significant competitive advantages as they understand the nuances and complexities of local markets in ways global competitors may not. In Egypt, for example, **Uber** eventually acquired local competitor **Careem** for $3.1 billion (a premium valuation) after failing to gain significant share on its own. Startups in emerging markets include **Grab** and **Gojek**, the largest ridesharing and fintech platforms in Southeast Asia. Smaller ridesharing competitors in Southeast Asia include **Go-Viet**. South Asia represents another area of opportunity, where venture-backed startup **Ola** has begun operating its own fleet of electric vehicles. In South America, local companies including **Cabify** compete with **Uber** and **Didi Chuxing**.

Europe: While efficient and widely used public transportation and strict regulations complicate the European market, we still see sizable growth ahead. **Uber** management views Europe as a 1.9 trillion-mile total addressable market opportunity, or roughly 54% of the US opportunity, and we view ridesharing as a potential alternative for medium-length trips in some European cities. We believe the largest markets in Europe include Germany, the UK, Scandinavia, France, and Italy. The largest VC-backed European ridesharing companies include **Cabify**, **BlaBlaCar**, **Bolt**, and **Heetch**.

Fintech services: Facilitating payments and offering other financial services can be a key differentiator for mobility platforms that can drive stickiness and cross-sell opportunities. **Seamless** payment processing was a key driver of **Uber**'s early adoption in the US and Europe. In Southeast Asia and South America, mobility tech companies such as **Grab**, **Ola**, **Rappi**, and **Gojek** have moved into fintech; and China's WeChat and Alipay offer wide-ranging services from payments to ridesharing.

Niche ridesharing: Many startups are focused on providing user-specific ridesharing services, such as female or child-focused ridesharing. Companies offering ridesharing services for minors include **Zum** and **HopSkipDrive**. These platforms target parents and provide on-demand or pre-arranged transportation services to shuttle children between school and other activities. Drivers on these platforms are typically thoroughly vetted with more stringent background checks and training. Brazil-based **Lady Driver**, which raised a seed round in June 2018, and Canada-based DriveHER match female drivers to female passengers to provide a safer rider experience. Long-range ridesharing platforms, such as **Hitch Technologies**, focus on matching multiple riders to drivers taking longer trips. Ridesharing app **Wingz** focuses on prescheduled airport rides and creating personal relationships between travelers and drivers.

Considerations

Labor regulation and minimum wage rules: Rising driver wages and scrutiny of gig-labor could pressure ridesharing business models. California's AB 5 entitles gig-economy workers to receive a minimum wage and other benefits and makes it more difficult for ridesharing and food delivery companies to classify workers as independent contractors. While **Uber** and **Lyft** will likely continue to contest the legislation, we expect it will put negative pressure on margins as drivers receive more pay. In August 2018, New York effectively set a minimum wage requirement for drivers and a cap on licensed vehicles. Other US cities also reportedly exploring a mandated minimum wage for **Uber** and **Lyft**

drivers. To the extent ridesharing companies in the US raise prices to offset labor cost increases, this could slow adoption and growth rates.

Big Tech poised to disrupt ridesharing incumbents: In our view, self-driving presents an existential risk to incumbent ridesharing providers. From our research, we have concluded that ridesharing companies such as **Uber** and **Lyft** are well behind the leading players in terms of their autonomous technology. Although vehicle autonomy is likely many years off, we view missing out on this technology as an existential risk for ridesharing incumbents. A nightmare scenario for **Uber** and **Lyft** would be one in which **Waymo** develops its own network, perhaps by leveraging the userbase of Google Maps, and Amazon gives free **Zoox** rides to Prime subscribers, leaving consumers with little reason to stick with the existing ridesharing companies. We believe this risk to ridesharing companies is underappreciated by the market, which is myopically focused on near-to-medium term business results.

Little room for new entrants in ridesharing: **Uber** and **Lyft** dominate the US market and benefit from significant network advantages, which would be hard for competitors to replicate. Given the upfront investment required to enter this market, we believe it is becoming increasingly difficult for early-stage VCs to justify backing new players against the scale and footprint of incumbents. Investors may also be averse to the long holding periods inherent to ridesharing companies; the poor public stock performance for both **Uber** and **Lyft** are likely further deterrents. The hesitance to invest in early-stage ridesharing startups may help insulate incumbents from disruption. We see upside potential in more nascent mobility segments, such as micromobility and carsharing.

Diversification requires investment, pressures margins: As automakers, ridesharing companies, and investors seek diversification with last-mile, micromobility, and other mobility-as-a-service solutions, this will require significant investment into new products and untested markets, pressuring margins and adding uncertainty.

Consumer-driven recession will stress model: The current crisis is expected to significantly pressure most ridesharing businesses. Local travel for consumer and business reasons has decreased significantly as health concerns remain, decreasing demand for rideshare services, especially when alternatives (such as working and ordering from home) are an option. While we expect the industry will gradually recover, the impacts will likely be significant.

Outlook

Ridesharing middlemen to gradually begin owning more transportation assets: Ridesharing platforms **Uber** and **Lyft** have operated primarily as software intermediaries connecting riders to drivers, effectively outsourcing the costs of fleet management. However, as regulation in the US increasingly targets ridesharing companies' use of contracted labor, this cost arbitrage may be short-lived.

For this reason, we believe the next stage of growth for mobility tech will be characterized by the expansion of asset-intensive fleet-based models that connect people directly to transportation assets, be they rental cars, bikes, scooters, or ridesharing services. While these business models tend to have lower margin profiles, their viability could increase alongside advances in electrification and autonomous driving technology, the introduction

of more durable transportation assets, and the continued evolution of private-public partnerships to promote mobility services.

More ridesharing companies will diversify into delivery: We believe rising demand for food and grocery delivery presents another opportunity for ridesharing providers. The demand for **Uber** Eats has accelerated significantly, with 113% YoY gross bookings growth in Q2, with restaurant partnerships growing more than 50% YoY. Delivery can help offset declines in core ridesharing revenue and potentially help drive an additional long-term growth channel, though building out in-app delivery functionality, partnering with food and grocery vendors, and attracting users are costly undertakings that could prompt consolidation in the industry.

Uber's management team has expressed its intent to bolster investment into grocery delivery both through the **Uber** Eats business as well as through the company's acquisition of **Cornershop**, a Latin American grocery delivery app. **Uber** has since acquired **Postmates** as part of a wave of consolidation among online food delivery apps in North America. **Uber** management has indicated that its business will now be split 50-50 between ridesharing and food delivery.

The trend has been similar internationally. In March 2020, **Didi Chuxing** launched a food delivery service in over 20 cities in Asia, and in early April the company entered the multibillion-dollar Japanese restaurant market with heavily discounted food delivery services. This represents a notable turnaround in strategy for the company, which scaled back its food delivery ambitions in 2019 amid pressure from investors to streamline costs.

Ridesharing to augment mass transit: As public transportation systems face financial strain, we anticipate cities will increasingly partner with ridesharing and shared mobility services as a means to pick up the slack during shutdown and off-peak hours. For example, **Uber** has reportedly partnered with transit agencies in at least eight markets due to the current crisis. In a few US markets, transit agencies are subsidizing **Uber** rides, which transportation officials claim has enabled them to save money by reducing insurance and fuel costs related to the maintenance of nearly empty buses. In late March, shared mobility provider **Via** announced partnerships with multiple cities, including Berlin and Abu Dhabi, to provide essential healthcare workers with transportation during off-peak hours. In early April, the city of Portland in the US announced a partnership with **Spin** to waive per-vehicle municipal fees to keep e-scooters available for commuters.

SEGMENT DEEP DIVE

Micromobility

Overview

Micromobility services address the problems of “last-mile” personal transportation by supplying small non-car modes of transport. While the industry began with shared bikes, focus has shifted to e-scooters that incorporate IoT technology to give low-cost urban transportation solutions. Subsegments in micromobility include:

Operators: Platforms and services that run shared networks of electric bikes, scooters, and other small vehicles.

Vehicle suppliers: Manufacturers of bicycles, scooters, and other small vehicles intended for urban transportation

Enablement technologies: Providers of tools and services augmenting the micromobility ecosystem. These include:

- Management and analytics platforms
- Booking aggregators
- GPS positioning

Industry drivers

Convenience and affordability: Micromobility solutions have many advantages when compared to ridesharing and traditional means of transportation, including convenience and cost effectiveness. A recent study found that bikes are faster than taxis for more than 50% of trips during peak midday hours in New York City.[6] Micromobility trips also tend to be cheaper than equivalent rideshares, with high accessibility at an average of two to three scooters per 100 people in mature markets such as San Diego and Austin in the US.

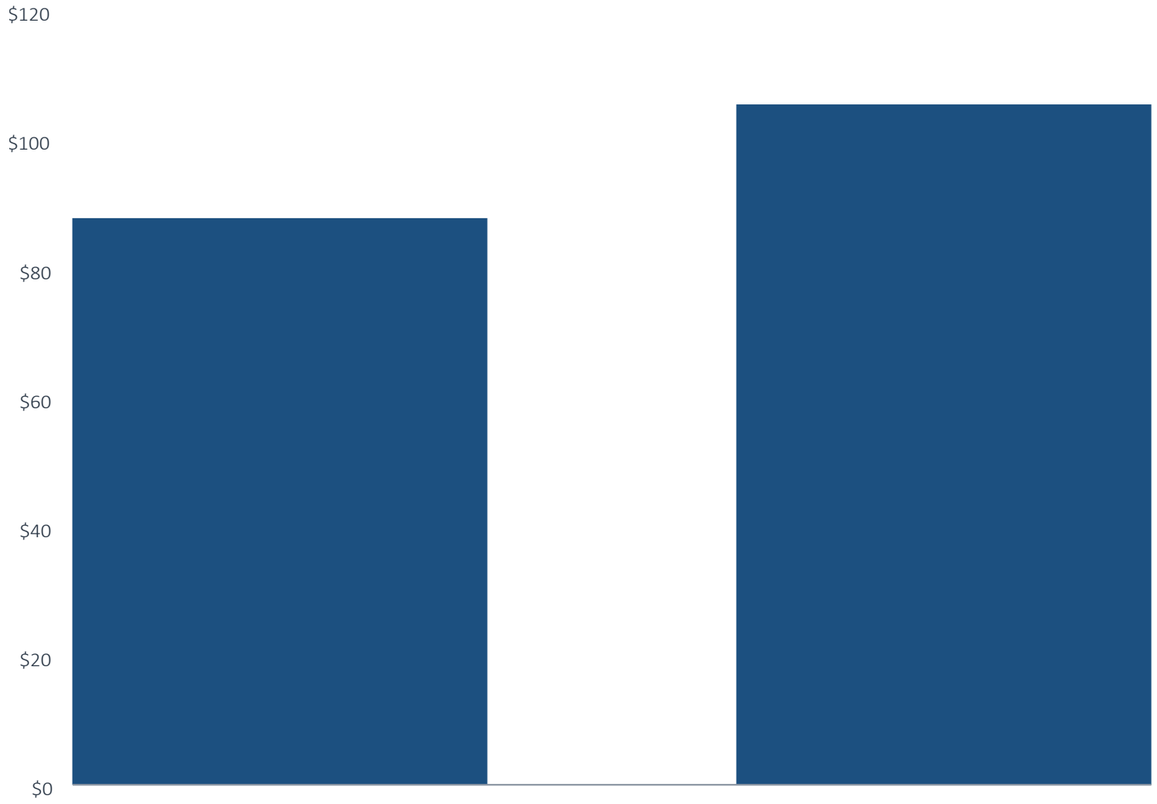
Increased adoption by cities: E-bikes and e-scooters can help ease congestion in overcrowded cities, especially as these vehicles draw consumers away from cars and public transportation. Many cities have begun funding or partnering with micromobility operators to limit car-based congestion and emissions, and we see signs that the regulatory environment is improving in other cities as well. Chicago in the US has partnered with **Lyft**-owned Divvy, a bike-sharing system expected to grow to 16,500 bikes by 2021. In early April 2020, New York legalized e-bikes and e-scooters to help delivery workers during the crisis.

Market size

We forecast the global micromobility industry will represent a $105.0 billion total addressable market by 2030. A primary driver of this industry will be the expanding global middle-income population as more people move to the world's cities and urban locations. 23% of people in 2018 lived in a city with more than 1 million inhabitants; that number is projected to increase to 28% by 2030.[7] Homi Kharas of the Brookings Institute

Figure 26.

Micromobility total addressable market size ($B)



Source: PitchBook | Geography: Global

6: "When Are Citi Bikes Faster Than Taxis in New York," Todd W. Schneider, September 26, 2017
7: "The World's Cities in 2018: Data Booklet," United Nations, Department of Economic and Social Affairs, Population Division, 2018

forecasts the global middle class to grow to 5.2 billion people in 2028 from 3.2 billion in 2016.[8] 88% of those new entrants will be habitants of Asia, in countries such as India, China, Indonesia, and Vietnam.[9] We see relatively higher growth opportunities within these emerging regions relative to more mature countries.

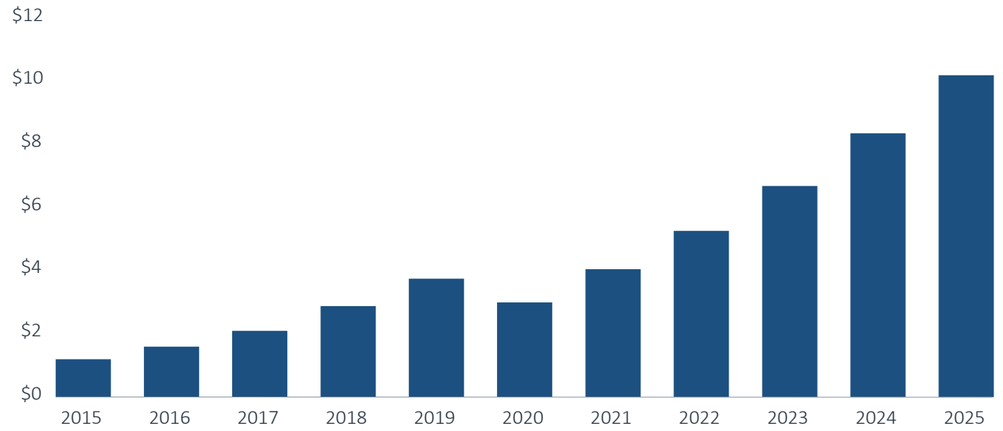
Our analysis of the total addressable market incorporates the growth of the global population within urban settlements and assumes a market penetration rate among these settlements based on population density. We assume urban centers of greater than 500,000 people can support an average of two micromobility units per 100 people, which is in-line with scooter penetration in mature markets in US cities such as San Diego and Austin. Among settlements with lower density, we assume a market penetration of one unit per 100 people. This drives a total global unit population of 78.6 million in 2030. We also assume each unit can generate an average revenue of $1,342, based on differences in global purchasing power. This leads us to our global total addressable market estimate of $105.0 billion and US equivalent of $32.0 billion. As the global market for shared micromobility is currently under $5.0 billion, we see a long runway of growth ahead.

Business model

Micromobility operators create and operate shared networks of electric bikes, scooters, and other small vehicles. These companies monetize by charging rental or subscription fees. Technology enablers such as data analytics platforms and positioning tool providers sell software to network operators, typically on a subscription and/or per-vehicle basis.

8: The Unprecedented Expansion of the Global Middle Class: An Update, Brookings Institution, Homi Kharas, February 28, 2017
9: Ibid.

Figure 27. MICROMOBILITY MARKET SIZE ($B)



Source: PitchBook | Geography: Global
Note: This represents global revenue for micromobility service providers.

Figure 28. COMMON INDUSTRY KPIS

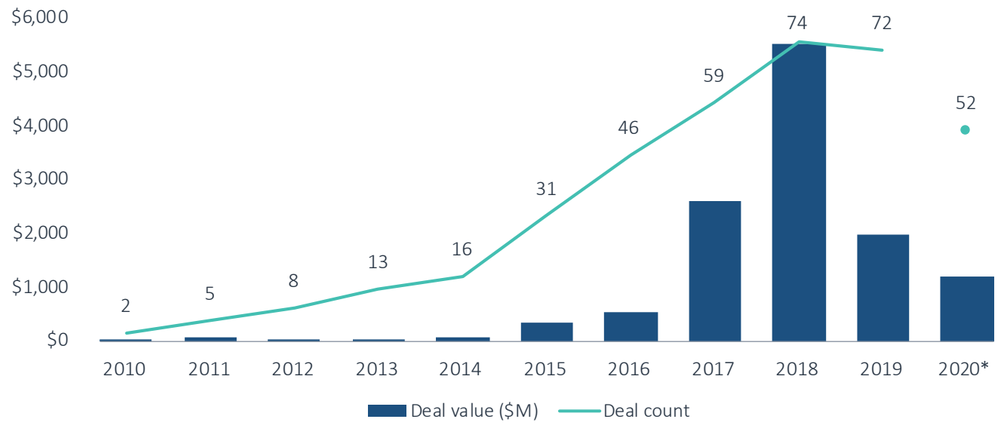
- Scooter life (days operational before replacement)
- Rides per day
- Net revenue per ride
- Scooter cost
- Charging cost per ride
- Repair cost per ride
- Payment processing and insurance cost per ride
- Contribution margin %
- Customer acquisition cost (CAC)
- Monthly active users (MAUs)

VC activity

Investment into micromobility declined substantially in 2019, driven by concerns around unit economics, regulation, and the overall defensibility of the industry. 2020 appears to be a continuation of that trend, with aggregate funding on pace to decline YoY.

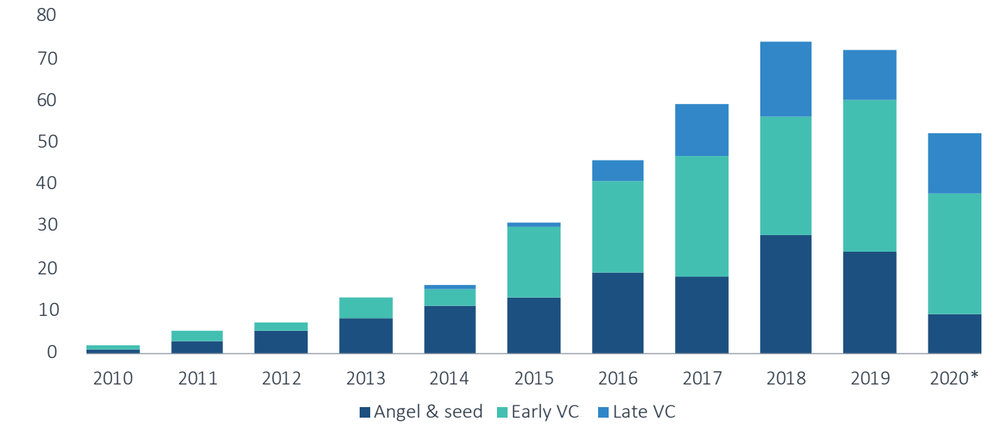
In Q3 2020, venture investment into micromobility startups totaled $214.7 million, down 67.8% QoQ and 82.2% YoY. However, deal count was up 11.1% QoQ and 17.6% YoY, suggesting that early-stage startups may be attracting VC dollars. Compared to other mobility tech sectors, micromobility is relatively nascent, with most deals closing at the early stage. Major deals in the quarter include Vanmoof's $40.3 million Series B in September, **Neuron Mobility**'s $30.5 million Series A round in September, and Marti's $27.4 million early-stage round in July.

Figure 29. MICROMOBILITY VC DEAL ACTIVITY



Source: PitchBook | Geography: Global | *As of September 30, 2020

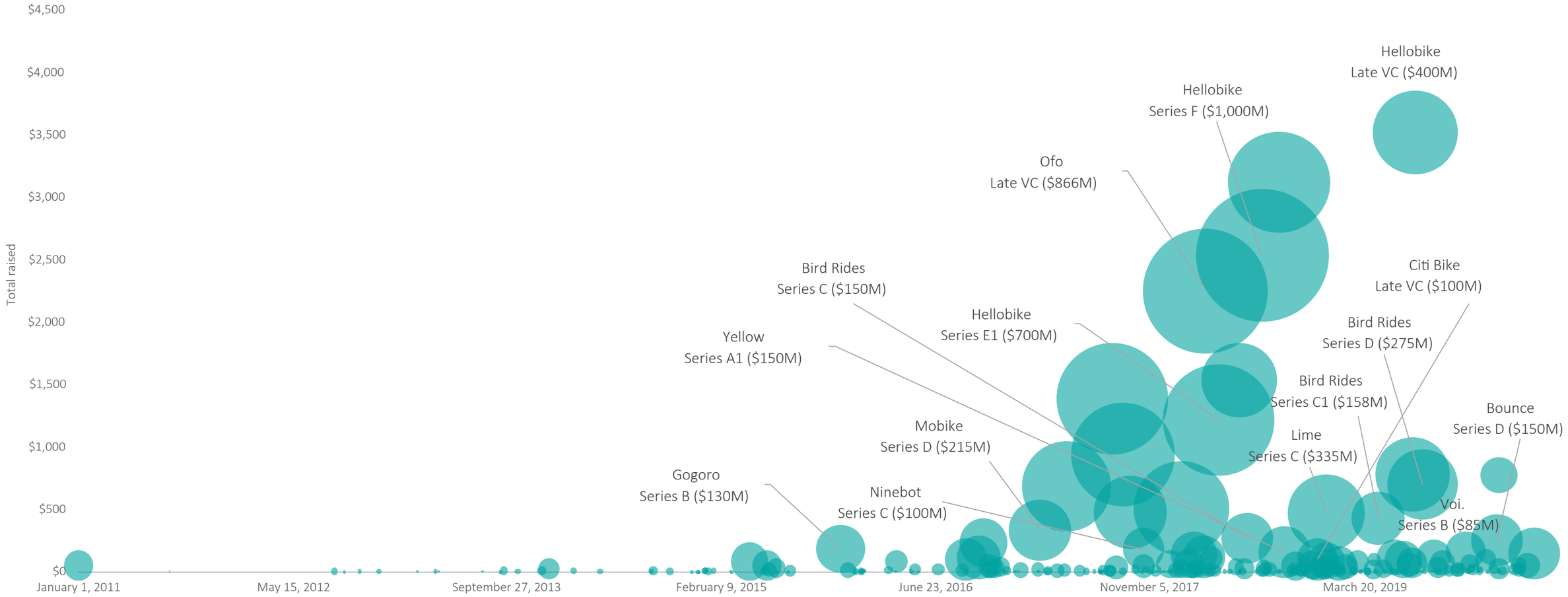
Figure 30. MICROMOBILITY VC DEALS (#) BY STAGE



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 31.

Micromobility VC landscape ($M)



Source: PitchBook

Note: The left axis indicates total VC raised as of deal date. Bubbles indicate amount raised.

MICROMOBILITY

Figure 32.

Notable micromobility VC deals

COMPANY NAME	CLOSE DATE	SUBSEGMENT	DEAL SIZE ($M)	POST-MONEY VALUATION ($M)*	DEAL STAGE	LEAD INVESTOR(S)
VanMoof	September 16, 2020	Vehicle suppliers	$40.3	N/A	Series B	N/A
Neuron Mobility	September 29, 2020	Network operators	$30.5	N/A	Series A	GSR Ventures, Square Peg Capital
Marti	July 25, 2020	Network operators	$27.4	N/A	Early-stage VC	N/A
Cowboy	July 23, 2020	Network operators	$26.0	N/A	Series B	EXOR Seeds
GoTo	July 15, 2020	Booking aggregators	$19.0	$30.0	Series B	166 2nd Financial Services
Movo	August 28, 2020	Network operators	$15.4	N/A	Corporate	N/A
Ather	July 27, 2020	Vehicle suppliers, electric vehicle platforms	$11.2	$337.5	Corporate	N/A

Source: PitchBook | *As of September 30, 2020

Figure 33.

Notable micromobility VC exits

COMPANY NAME	CLOSE DATE	SUBSEGMENT	EXIT SIZE ($M)	POST-MONEY VALUATION ($M)*	EXIT TYPE	ACQUIRER(S)/INDEX
Pushme	February 13, 2020	Other micromobility	N/A	N/A	M&A	TIER Mobility
Boosted USA	April 17, 2020	Vehicle suppliers, electric vehicle platforms	N/A	N/A	M&A	Lime
Etergo	May 27, 2020	Network operators	N/A	N/A	M&A	OLA Electric

Source: PitchBook | *As of September 30, 2020

Figure 34.

Key VC- and PE-backed micromobility companies

COMPANY NAME	TOTAL VC RAISED ($M)	SUBSEGMENT
Lime	$947.1	Network operators
Bird Rides	$776.0	Network operators
Gogoro	$480.0	Network operators
Bounce	$247.6	Network operators
Voi.	$167.9	Network operators
TIER Mobility	$159.0	Network operators
Passport	$124.0	Parking, management & analytics platforms
Superpedestrian	$118.9	Network operators
Citi Bike	$100.0	Network operators
Cityscoot	$92.2	Network operators
WIND Mobility	$72.0	Network operators
VanMoof	$70.7	Vehicle suppliers

Source: PitchBook | *As of September 30, 2020

Opportunities

Late-stage network operators: We believe late-stage investment opportunities exist with leaders such as **Bird** and **Lime**. Other major players include companies such as **Spin** (**Ford**) and Motivate (**Lyft**). We view the relative stability in revenue per ride as reported by **Bird**, **Lime**, and **Uber** as positive indicators of strong demand and rational pricing dynamics.

Bird and **Lime** are pursuing slightly different international growth strategies that in some ways mirror ridesharing giants **Lyft** and **Uber**. Similar to **Lyft**, **Bird** is taking a more cautious, asset-light approach to international market expansion by selling scooters to local operators in markets including New Zealand, Canada, and Latin America under a revenue share model. Meanwhile, **Lime** is taking a more aggressive, **Uber**-like approach by expanding rapidly overseas in regions such as Western Europe. Leading European micromobility players include TIER, Voi, Dott, Nextbike, and **WIND Mobility**.

Emerging markets: Providers targeting high-growth, lower-middle-income international markets could benefit from urbanization and the expansion of the middle class. In countries such as Vietnam where most transactions are dominated by cash payments, providers that can encourage electronic payments may have an edge. We see opportunity in startups such as **Circ**, **Vogo**, **Bounce**, **Grow Mobility** (which arose out of the merger between Brazil-based **Yellow** and **Grin**), and **Neuron Mobility**.

Positioning systems: Advanced positioning and localization tools enable micromobility providers to locate and track scooters in urban environments. Current GPS solutions on the market today are imprecise, with accuracy ranging from three meters to over 10 meters, making it harder for consumers to find bikes and scooters and difficult for fleet operators and city officials to monitor them. Improved GPS solutions could help reduce the use of scooters on sidewalks and ensure they are parked properly.

Startup **Navmatic** has developed a cloud correction service and positioning engine that provides submeter-level accuracy using sensor fusion and multipath mitigation algorithms. Startup **Fantasmo** has an alternative approach, with an augmented reality solution that combines previously mapped city streets with camera inputs to identify scooters illegally ridden on sidewalks or incorrectly parked. While **Fantasmo** boasts centimeter-level positioning, we believe the company may need to develop a lower-cost solution to gain more adoption.

Analytics platforms: Fleet management tools enable network operators to set up operations and manage their fleets. Companies in this space include **Superpedestrian**, **Joyride**, **Zagster**, and Fleetbird (acquired by **Wunder Mobility**). The "**Bird** Platform" enables entrepreneurs to manage their own branded fleet of scooters via **Bird**'s network under a revenue share model. The service has helped **Bird** expand to emerging and international markets with considerably less investment in hardware and marketing. **Zoba** is another key company in the space that has developed a data analytics platform to help network operators forecast demand and maximize utilization. We also see a need to help cities and other third parties monitor and track scooter usage, parking patterns, and sidewalk usage. This can help cities make more informed decisions about how to design and deploy infrastructure such as bike lanes and parking zones. Startups such as **Ride Report**, **Passport**, and **Populus** offer SaaS solutions for city planners and network operators to share data with each other and other key stakeholders.

MICROMOBILITY

Predictive maintenance: Monitoring platforms that leverage IoT sensors with AI & ML-based risk assessment algorithms can proactively predict and prevent micromobility battery failures. For example, platforms could monitor battery voltage in real time to identify e-scooters at risk for component failure and proactively signal technicians to fix problems before they arise.

Electric mopeds: The next micromobility iteration could be shared electric mopeds. While mopeds could serve a niche market for longer-distance urban trips, utilization remains a lingering concern. Relative to moped-friendly markets in Southeast Asia and Europe, US consumers are less accustomed to riding mopeds, which is more akin to riding a motorcycle than an e-scooter.

While pricing remains comparable to e-scooters, e-mopeds require parking, street driving, helmets, insurance, and a valid driver's license. Nevertheless, in October 2019, **Revel** raised a $27.6 million round for what we believe could be a viable model as the increased durability and longer lifespans of e-scooters help drive profitability. We estimate this could be a mid-teens contribution margin business—below e-scooters but attractive compared to other mobility industries such as ridesharing and food delivery.

Mopeds have been successful in Asia, where **Gogoro** holds 17% market share of all vehicles sold in Taiwan. **Gogoro** has entered the shared mobility space with its GoShare platform, which enables users to share electric mopeds and easily swap depleted batteries at charging kiosks found at gas stations, retail stores, and cafes.

Electric vehicle charging: Micromobility charging stations will be needed to service the rise of shared electric bikes and scooters in much the same way gas stations benefited from the rise of the automobile. Startups in this space, such as **Swiftmile** and **ChargePoint**, are building charging, storage, and service station networks that integrate with micromobility network operators. We believe partnerships with other service networks represent an important strategy for providers seeking to create the best consumer experience. Although this could be a large market opportunity, electric charging is typically a low-margin, hardware-focused business model. First movers are likely to have an advantage as they scale, as evidenced by **ChargePoint**'s success in electric car charging.

Autonomous technology: Autonomous technology has the potential to significantly improve the unit economics of micromobility. We estimate that approximately 20%-30% of net revenue goes toward charging costs, which consists of employing workers to manually swap out depleted batteries. Automating other manual processes such as loading scooters into trucks and moving them to different locations could also drive significant labor savings. We believe automation of micromobility is in early stages and large-scale deployment will depend on advances in the technology and significant decreases in the cost of perception systems such as lidar. However, safety requirements could be lower as these vehicles will travel at slower speeds without passengers. One leader in the space is scooter supplier **Ninebot**, which in August 2019 unveiled a scooter that can autonomously return to charging stations. Other companies working on autonomous scooters include Tortoise and **Etergo**.

Personally owned vehicles: E-skateboard and electric unicycle manufacturers such as **Boosted** and **OneWheel** have seen growth in recent years. These companies do not operate networks of shared vehicles and instead rely on direct-to-consumer sales. While still reflective of the thematic shift away from car ownership, we view direct vehicle sales as a less attractive market opportunity relative to providing scalable transportation platform services.

Considerations

Regulation: Unlike alternative mobility business models such as ridesharing where vehicles are driver owned and operated, cities have much more leverage over micromobility companies and can impound vehicles or ban micromobility operations. Several major cities in the US have limitations or outright bans on the operation of dockless bikes and scooters. Although some of these municipalities have pilot programs and are inching toward legalization, this uncertainty casts a cloud over the future of the industry.

Despite these setbacks, we believe the dialogue has become much more constructive, and city officials are more frequently engaging and working with micromobility providers to analyze scooter traffic data for infrastructure improvements. Both Seattle and San Antonio in the US have announced plans to set up digital parking zones for bikes and scooters at intersections and other convenient drop-off points. In September 2019, San Francisco gave permits to **Jump**, **Lime**, **Scoot**, and **Spin**, allowing a maximum of 10,000 e-scooters citywide. We believe many of the concerns around littering and sidewalk clutter are transitory and will be resolved as providers improve how they track and place scooters. Ultimately, we believe city officials recognize the potential for micromobility to improve congestion and reduce noise pollution and emissions while providing a useful service for citizens.

The challenges fleet maintenance and operations: Unlike ridesharing applications where maintenance and upkeep are passed on to drivers, bike and scooter fleet operators are responsible for keeping their fleets in working order. A successful fleet-based model necessitates predicting consumer traffic patterns, moving vehicles to high-utilization areas, and providing charging and repair networks. Other challenges include a capital-intensive model, ongoing equipment maintenance costs, supply chain risk (i.e., manufacturing costs, tariffs), seasonality (i.e., bad weather decreases use) and lower barriers to entry for competitors. Depreciation, reliability, and durability of the vehicles are also important considerations for the long-term health of these companies.

Outlook

Larger form-factor vehicles to expand market opportunity: We are relatively more optimistic about larger form-factor micromobility vehicles such as e-mopeds relative to e-scooters. Vandalism and damage represent significant cost headwinds for micromobility startups. Larger form-factor vehicles such as e-mopeds tend to be more durable relative to e-scooters, helping startups generate better contribution margins and faster payback periods. Additionally, the latest micromobility data suggests that consumers are increasingly taking longer trips, a shift that favors larger, on-road forms of micromobility such as e-mopeds. We are optimistic about shared e-moped startups **Revel** and **Gogoro** and expect them to benefit from increased demand and better margins.

Dynamic pricing to become more standard: We believe the upcoming shift to dynamic pricing will improve micromobility unit economics, while increasing utilization and adoption. Unlike most mobility tech services that have surge-pricing features, micromobility has used fixed prices. As the industry shifts to swappable batteries, the need to “rebalance” fleets by moving them to areas of high demand becomes less necessary. Instead, we believe operators will increasingly incentivize trips to high-utilization areas using fare discounts. This has the potential to reduce the need for workers whose job is to relocate bikes, scooters, and other vehicles, potentially increasing

margins. One potential beneficiary of this trend could be data analytics company **Zoba**, which recently launched a dynamic pricing product specifically tailored for micromobility and carsharing applications.

Micromobility poised to draw commuters from public transit: Although the reduced movement of people presents a headwind to micromobility in the near term, we believe the industry could benefit in the medium term as economic activity picks back up and people return to work. Micromobility could draw urban commuters away from public transit as e-bikes and e-scooters provide a potentially safer alternative for those wary of sharing spaces with others. This could drive significant growth and could meaningfully expand the market for micromobility, which we estimate has a total addressable market of $32 billion in the US and $105 billion globally. We delve into this dynamic in-depth in our Q2 research note **COVID-19: A Watershed Moment for Shared Mobility**.

Social distancing to positively reframe the debate over micromobility: Micromobility could play an important role in helping cities incorporate social distancing practices for commuters, while also solving existing issues related to congestion and emissions. Up until now, demand for bike lanes has generally been gauged by estimating how many commuters are willing to ride bikes and scooters on busy streets with heavy traffic—an approach that assumes streets will remain congested with cars. The pandemic gives city planners an opportunity to gauge how commuters might use micromobility services in an environment with fewer cars. According to Micromobility Industries, more than 200 cities globally have partially or fully closed down streets in order to create wider footpaths and bike lanes. Major European cities are setting up permanent car-free zones. For example, London is closing significant portions of the city to cars to reduce congestion and emissions as the city comes out of lockdown. These initiatives could help shape how city planners determine whether to build bike lanes and other infrastructure amenable to micromobility services.

Shakeout to favor corporate-backed, capex-light operators: While we would not be surprised to see a material shakeout in the micromobility space over the next few months, better-capitalized providers such as **Ford**-owned **Spin** could gain market share as cash-strapped micromobility startups are forced to suspend operations. While **Bird** and **Lime** have recently pulled scooters from markets in the US and Europe, **Spin** has maintained operations in certain markets, even offering free transportation services to healthcare workers. Additionally, we believe platforms with relatively lighter capital-expenditure needs should be better positioned to navigate this storm. These include European micromobility operators such as Tier and Voi, which use contracted delivery companies to move vehicles, as compared to US-based providers **Bird** and **Lime**, which rely on in-house operations teams.

SEGMENT DEEP DIVE

Auto commerce

Overview

Auto commerce providers enable consumers to buy, sell, and rent cars online via mobile apps. These companies provide marketplaces that match drivers to cars, supply financing and insurance, and facilitate payment processing.

Digital marketplaces provide websites where consumers can buy new and used cars from dealerships or other consumers. Other platforms such as **Carwow** and **Joydrive** offer car price comparison services, online reviews, and searchable databases. Online dealerships such as **Shift** and **Carvana** purchase, refurbish, and resell vehicles.

Financing apps supply short-term leases and subscription-based vehicle ownership options. Startup **Fair** grants leasing options to rideshare drivers, with features including the flexibility to end a lease prematurely without penalty or switch to a different vehicle. Several European automakers such as Volvo and **Daimler** have begun offering vehicle subscription services. In the US, **Canoo** has generated considerable interest in its subscription-based electric vehicle platform.

Carsharing businesses consist of traditional carsharing, much like car rental, and emerging peer-to-peer (P2P) models. Under the traditional fleet-owned model, a fleet manager such as **Zipcar** or GIG Carshare owns and operates the vehicles and makes them available through a mobile app. Pickup and drop-offs occur either at designated stations or, in the case of free-floating carsharing, anywhere within an operational area. Under the P2P model, applications such as **Getaround** and **Turo** enable car owners to rent their personal vehicles to others.

Industry drivers

Expanding market for flexible vehicle usage: Emerging mobility technologies are reducing the need for consumers to own cars and creating an opportunity for auto commerce app providers to introduce alternative mobility solutions. Online dealerships, carsharing, and online subscription apps generally enable consumers to gain access to cars at lower cost and with less friction relative to traditional car dealerships and rental companies, which have larger overhead associated with physical retail locations.

Pandemic-induced demand for online car buying: We believe many consumers, particularly in North America, will move from mass transit to personal vehicle ownership in the near term. Online car buying apps facilitating contactless vehicle purchases should benefit from this trend. In European and Asian markets where car ownership is less affordable and practical relative to North America, we see a greater move toward shared mobility alternatives and flexible vehicle ownership models.

Improving ecommerce technology: Consumers today are more comfortable than ever purchasing products online. As car-buying apps continue to improve the online purchasing experience, including the cumbersome and complicated tax, title, delivery, and financing processes, we expect adoption among consumers to accelerate.

Developing countries have lower rates of car ownership: Countries with lower rates of car ownership are likely to be fertile territory for auto commerce apps, which allow consumers to more easily and cheaply rent cars.

Part of gradual transition to autonomous and shared vehicle fleets: As shared service platforms and autonomous vehicles become a more important part of the transportation ecosystem, automakers developing carsharing applications may more easily adapt to the future of mobility.

Market size

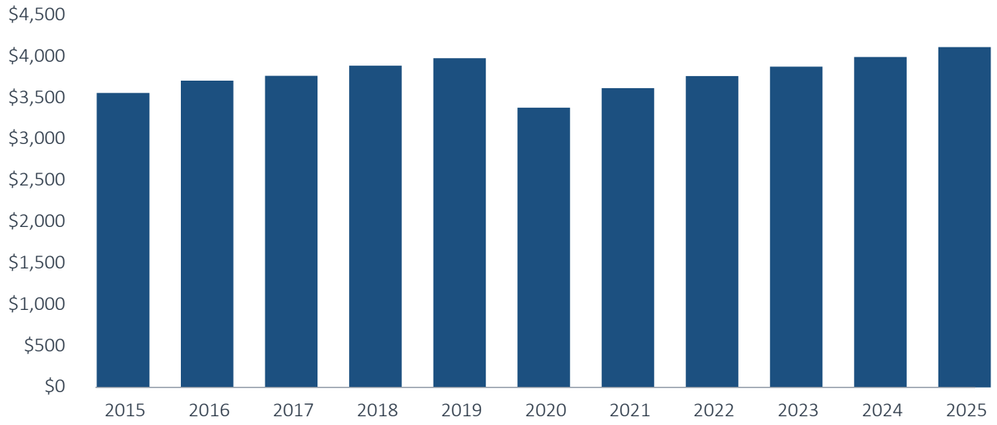
We estimate that global sales for new and used cars totaled approximately $4.0 trillion in 2019. We expect to see a pullback in 2020 driven by a 20% decline in global new-car sales YoY. Going forward, we anticipate the used-car market to outperform new-car sales due to dwindling consumer discretionary spending. Coming out of this crisis, we expect dealers and platforms providing contactless car-buying experiences to see faster market growth.

We believe the quickest growth driver for startups in this segment will come from sales of used cars moving online. We estimate that the global used-car market in 2019 totaled approximately $1.8 trillion, and we expect online car-buying apps to serve a $231.0 billion market by 2025 (up from approximately $14.0 billion today), representing 12.5% penetration of overall global used-car sales.

Business model

Digital marketplaces provide websites where consumers can buy new and used cars from dealerships or other consumers. Business models vary by platform. Some platforms such as **Shift** buy, refurbish, and sell vehicles, and then they record the difference between the selling and buying price as net revenue. Since these companies do not operate physical retail locations, these companies have less costs than incumbent dealerships. Software-focused platforms that do not hold inventory monetize by charging advertising fees to the seller. Finally, vehicle subscription and carsharing services monetize by charging drivers fees. P2P carsharing services distribute a portion of those fees to the vehicle owner.

Figure 35. AUTO COMMERCE MARKET SIZE ($B)



Source: Navigant Research, internal PItchBook estimates| Geography: Global
Note: This market size is based on total end-user spending.

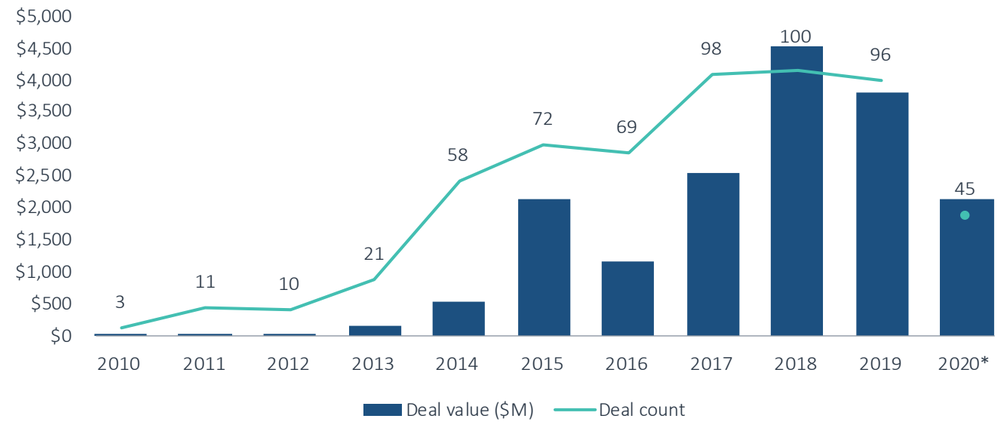
Figure 36. COMMON INDUSTRY KPIS

- MAUs
- Fleet size
- Car sales
- Vehicle utilization
- Parking partnerships
- Revenue per vehicle
- Profit per vehicle
- Contribution margin
- Market days supply
- Inventory turn rate

VC activity

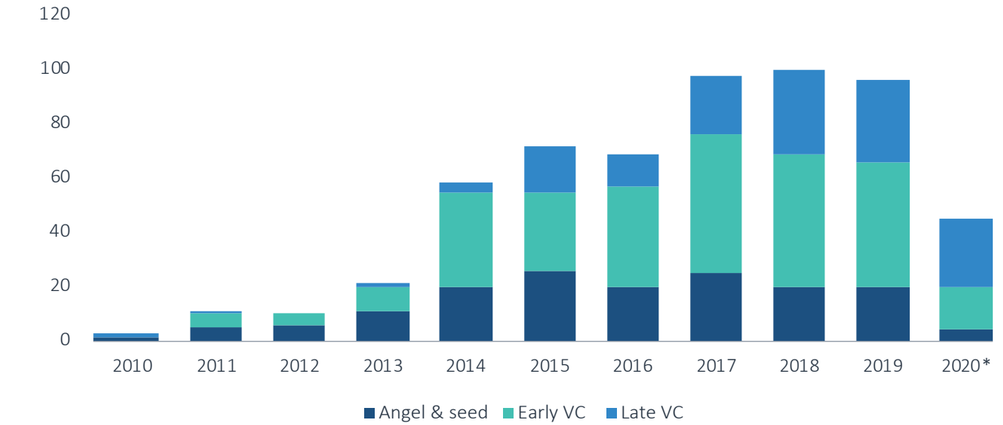
Auto commerce VC deal value in Q3 2020 totaled $879.2 million, up 14.5% QoQ but down 1.2% YoY. Top deals in the quarter include **Kavak**'s $397.2 million early-stage VC round in September, **AUTO1 Group**'s $291.3 million late-stage VC round in July, and **Carvolution**'s $55.0 million corporate VC round in September. Approximately 67% of investment this year went toward digital marketplace startups, while approximately 16% went toward carsharing apps. These totals are in line with previous levels and reflect sustained investor interest in digital auto commerce startups in a pandemic environment.

Figure 37. AUTO COMMERCE VC DEAL ACTIVITY



Source: PitchBook | Geography: Global | *As of September 30, 2020

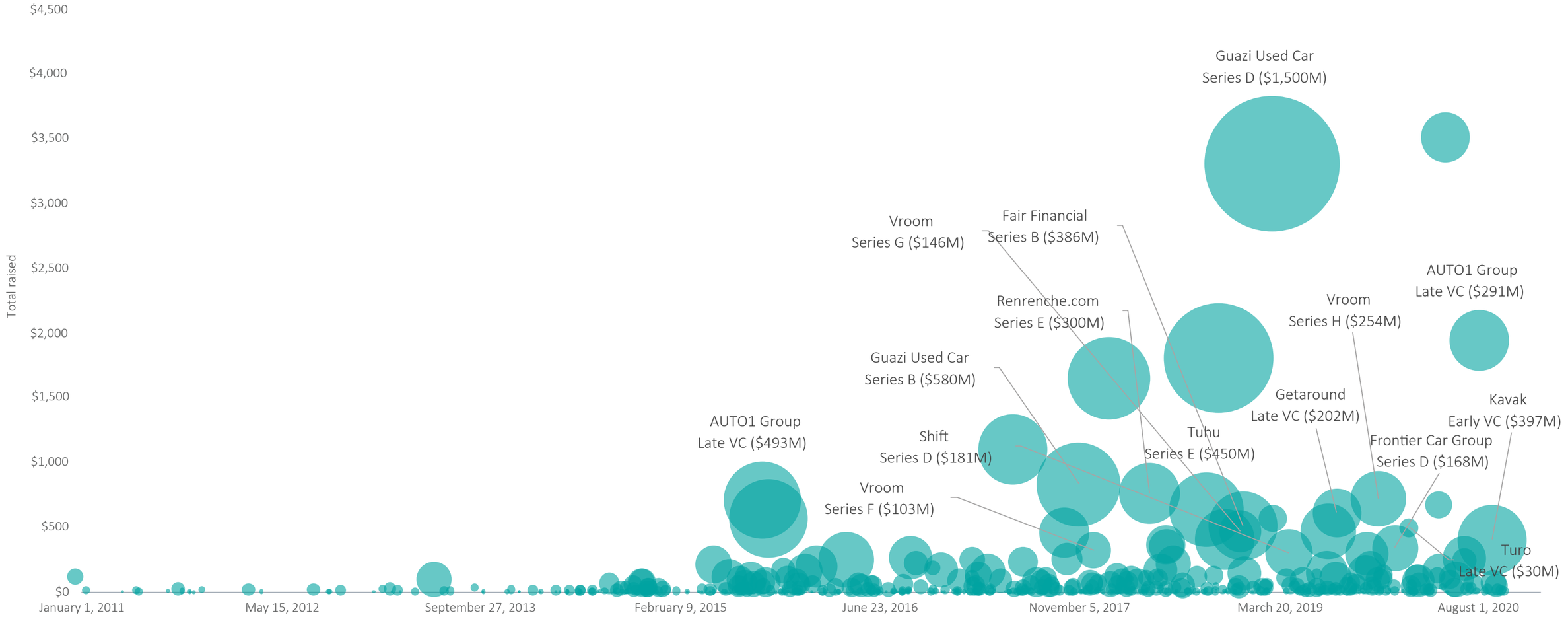
Figure 38. AUTO COMMERCE VC DEALS (#) BY STAGE



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 39.

Auto commerce VC landscape ($M)



Source: PitchBook

Note: The left axis indicates total VC raised as of deal date. Bubbles indicate amount raised.

Figure 40.

Notable auto commerce VC deals

COMPANY NAME	CLOSE DATE	SUBSEGMENT	DEAL SIZE ($M)	POST-MONEY VALUATION ($M)*	DEAL STAGE	LEAD INVESTOR(S)
Kavak	September 1, 2020	Digital marketplaces	$397.2	$1,150.0	Early-stage VC	Greenoaks Capital Partners, SoftBank Group, DST Global
AUTO1 Group	July 30, 2020	Digital marketplaces	$291.3	N/A	Late-stage VC	Farallon Capital Management, The Baupost Group
Carvolution	September 4, 2020	Financing & subscriptions	$55.0	N/A	Corporate	N/A
Cluno	September 11, 2020	Carsharing	$42.7	N/A	Series B	Valar Ventures
Drover	July 16, 2020	Financing & subscriptions	$32.1	N/A	Series B	Autotech Ventures, RTP Global, Target Global
Spotawheel	September 15, 2020	Digital marketplaces	$11.8	N/A	Late-stage VC	VentureFriends
Modal	August 19, 2020	Financing & subscriptions	$11.2	$56.2	Series A	N/A

Source: PitchBook | *As of September 30, 2020

Figure 41.

Notable auto commerce VC exits

COMPANY NAME	CLOSE DATE	SUBSEGMENT	EXIT SIZE ($M)	POST-MONEY VALUATION ($M)*	EXIT TYPE	ACQUIRER(S)/INDEX
Vroom	June 9, 2020	Digital marketplaces Financing & subscriptions	$2,067.7	$2,535.2	IPO	NASDAQ
Autolist	January 16, 2020	Digital marketplaces	$21.0	$21.0	M&A	CarGurus
Carcrew	February 20, 2020	Repair & maintenance	N/A	N/A	M&A	TVS Group

Source: PitchBook | *As of September 30, 2020

Figure 42.

Key VC- and PE-backed auto commerce companies

COMPANY NAME	TOTAL VC RAISED ($M)	SUBSEGMENT
Guazi Used Car	$3,510.0	Digital marketplaces
AUTO1 Group	$1,942.0	Digital marketplaces
Renrenche.com	$760.0	Digital marketplaces
Getaround	$672.9	Carsharing
Tuhu	$635.0	Repair & maintenance
Fair Financial	$569.2	Financing & subscriptions, digital marketplaces
Turo	$496.0	Carsharing
Kavak	$400.5	Digital marketplaces
Chezhibao	$358.5	Digital marketplaces
Tiantian Paiche	$353.0	Digital marketplaces
Frontier Car Group	$337.0	Digital marketplaces
Shift	$302.8	Digital marketplaces

Source: PitchBook | *As of September 30, 2020

Opportunities

Used-car marketplaces: Marketplaces consist of ecommerce websites and mobile apps that facilitate transactions for buyers and sellers of new and used vehicles. Used-car marketplace platforms such as **Carvana**, **Shift**, and **Vroom** typically provide appraisal, loan payoff, and pickup services to sellers. Purchased vehicles are then inspected and reconditioned before being listed on the website. Once a transaction is complete, the purchased vehicle is delivered directly to the buyer's home. These apps often partner with lenders to provide financing services, which are integrated into the buying and selling process. This makes the purchasing process quick and free from the hassles and negotiations encountered at used-car lots, although buyers may have to wait several days before the car is delivered. Online buying apps also allow customers access to a larger inventory of cars that are often priced competitively, if not below the prices of those in used-car lots. For sellers, online marketplaces provide an on-demand buyer that can assist with loan payoffs as well.

P2P carsharing: P2P carsharing consists of consumers using an app to rent cars directly from car owners. Relative to traditional car rental agencies, P2P providers do not own and operate vehicles, eliminating the costs of fleet procurement and management. This creates a more easily scalable business model that has the potential to drive higher-margins. P2P carsharing is typically less expensive than traditional car rentals and creates a low-touch, seamless digital experience. Leading P2P carsharing providers in the US include **Turo** and **Getaround**.

Fleet-operated carsharing: Fleet carsharing providers own and operate a fleet of vehicles and make them available to consumers through a mobile app. Pickup and drop-offs occur either at designated stations or, in the case of free-floating carsharing, anywhere within an operational area. Fleet carsharing provides many of the same benefits to consumers as P2P carsharing (i.e., easy digital access to car rentals) but offers a more premium experience with newer vehicles available. Fleet carsharing may be more successful in European markets, where gig-economy worker protection laws can result in ridesharing prices that are two to three times higher than in the US, thus making carsharing a relatively competitive alternative. In addition to apps such as **Zipcar** and GIG Car Share, several European automakers, including **Daimler**, **BMW**, **Volkswagen**, **Groupe PSA** (the maker of Peugeot and Citron cars), and Volvo, have begun offering their own carsharing or subscription-based services.

Subscription services: Car subscription services provide another alternative to car ownership and traditional car rental. Car subscriptions enable consumers to essentially subscribe to the vehicles on offer from a car manufacturer or dealer. While subscriptions can be similar in price to traditional car leasing, car subscribers are not locked into a single vehicle for two to three years. They can instead switch to new cars more frequently. We expect providers to increasingly emulate a SaaS-model, where customers are constantly alerted to the latest vehicle updates. This model could be closer to reality for manufacturers of modular electric vehicles, such as **Canoo**, which plans to sell cars purely by subscription, inclusive of all maintenance, insurance, and related services.

Considerations

Low-margin business: Although online services likely have a long runway of revenue growth, auto sales is a structurally low-margin business. Companies in the space typically monetize by taking the margin between purchasing and refurbishing a vehicle and reselling it. As new competitors enter the market with similar digital platforms, these margins could

be pressured. Additionally, the current economic downturn could impair margins over the medium term as consumers cut back spending on higher priced (and higher margin) vehicles.

Carsharing faces competition from ridesharing: We believe fleet-operated carsharing is a difficult business model, particularly in the US, due to competition from cheap ridesharing services. Depreciation, repair, maintenance, fuel, and moving vehicles can have a major impact on margins. Recent exits of **BMW**'s **ReachNow** and LimePod from the market, as well as Car2go's departure from five North American markets, underscore the difficulty of this business as consumers largely opt for cheaper ridesharing alternatives. In Europe, where workers tend to have greater labor protections, ridesharing services are relatively more expensive, leading to more success among carsharing providers. The large number of OEM-backed carsharing operators in Europe has led to a price war in the region.

Need to create two-sided market: Digital marketplace startups need to be able to attract both car buyers and car sellers to build inventory. Failure to have enough of either makes it difficult for the business model to work. An important challenge in scaling startups in this space is balancing supply with demand and ensuring that one does not outstrip the other as new markets are added.

Outlook

Online car sales to take share from physical dealers, boosted by pandemic: We expect used car sales will gradually shift online as ecommerce penetrates the car-buying industry. The coronavirus pandemic has catalyzed demand for end-to-end contactless online car buying, including touchless financing approval and home delivery. Demand for used cars has recently increased, driven by aversion to mass transit and the contracted supply of new cars due to factory shutdowns. Online auto commerce startups such as **Shift**, **Blinker**, and **Digital Motors** are well poised to benefit from growth in this market as contactless car buying has many advantages over purchasing via traditional dealerships. Going forward, incumbent automakers and dealers must adapt by investing in online marketplace applications and dealership enablement technologies to succeed.

Carsharing to benefit from pandemic as incumbent car renters struggle: Carsharing applications have seen significant growth due to the coronavirus pandemic. Although the segment was originally expected to be pressured by declines in business travel, this headwind has been more than offset by a boost from socially distanced vacationing. With international travel limited and airline travel viewed as risky from an infection perspective, road trips have been popular among vacationers, and contactless carsharing apps benefiting from the trend. We believe startups such as **Turo** and **Getaround** are taking market share from the traditional car rental industry, which is struggling from its operations-heavy approach and dependence on business travel.

Shift to electric vehicles to improve unit economics: We expect the shift to electric vehicles will improve the unit economics for carsharing services and solve existing issues related to the high costs of owning and operating fleets of cars. Compared to traditional internal combustion engine vehicles, electric cars have lower operating costs since they do not require fuel and have far fewer maintenance needs. Ridehailing service Free Now (previously MyTaxi) has already switched a significant portion of its black cab fleet to electric taxis. We believe carsharing applications such as Upshift, GIG Carshare, and Envoy that focus on battery and hybrid-electric vehicles will be more successful than previous ventures focused on internal combustion engine vehicles.

SEGMENT DEEP DIVE

Last-mile delivery

Overview

Last-mile delivery providers focus on hyper-local delivery services that provide retailers with a unique way to deliver products to customers in short time periods. This segment includes third-party food and goods delivery services as well as technology providers that automate the delivery process.

Delivery services: Delivery platforms, such as **Uber** Eats, **DoorDash**, and **Postmates**, that contract couriers to deliver food, groceries, and other goods on-demand

Automated delivery: Autonomous delivery companies, such as **Nuro** and **Starship** Technologies, that develop robotic solutions to deliver goods without the need for a courier

Industry drivers

Consumer demand for faster delivery services: Emerging technologies that enable speedier delivery times stand to benefit from growing consumer preference for on-demand, same-day delivery services. In much the same way that ecommerce has taken share from physical retail, we believe on-demand food delivery may be taking share from traditional eat-in restaurants.

The rise of the gig economy: Emerging delivery platforms (e.g., **Grubhub**, **Uber** Eats, **DoorDash**, and Amazon) that connect vendors and consumers allow companies to gain access to an extensive pool of individual drivers ("gig economy" workers) who use their own vehicles to provide local delivery services on a contractual basis. This model can provide local delivery services with higher efficiency and at a lower cost compared to traditional delivery fleets.

Autonomous vehicles: While still several years away, we believe autonomous vehicle technology represents the next stage of delivery's evolution. These technologies include autonomous cars, robots, pods, and drones that have the potential to replace human couriers in serving the need for low-cost, last-mile delivery.

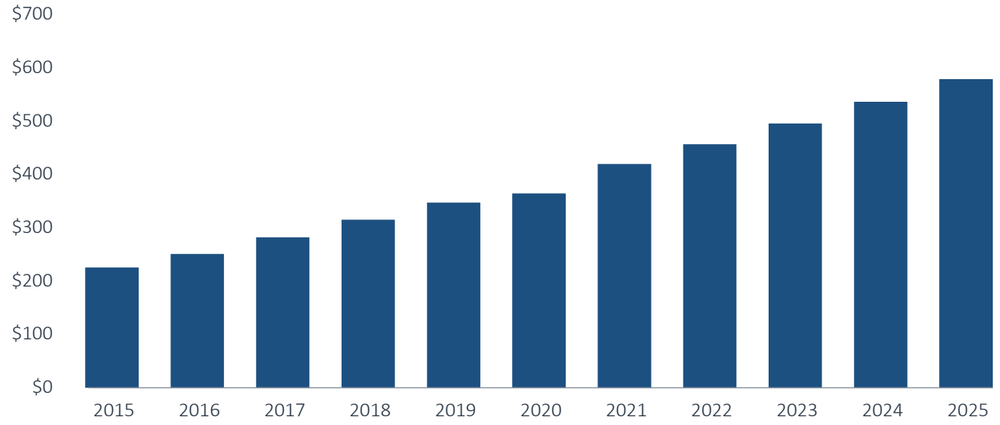
Market size

We estimate global revenue from last-mile delivery services reached approximately $347.0 billion in 2019 and forecast this to grow to $579.0 billion by 2025, implying a CAGR of approximately 7.7%. We expect consumer adoption of online food delivery to be one of the key drivers of increased growth in the industry. Although ecommerce volumes will likely be affected by reduced consumer spending, we anticipate the online food, grocery, and essential goods delivery industries will see a boost. Social distancing could expand adoption and attract more users, meaningfully expanding the market for online food and grocery delivery.

Business model

Last-mile delivery providers focus on hyper-local delivery services that give retailers a unique way to deliver products to customers in short time periods. This includes food delivery platforms such as **Uber** Eats, **DoorDash**, and **Postmates**, which contract with couriers to deliver food and groceries on-demand. These platforms tend to monetize by taking a commission of the gross transaction, in addition to charging an additional delivery fee or service charge to the diner. A percentage of these earnings are then

Figure 43. LAST-MILE DELIVERY MARKET SIZE ($B)



Source: PitchBook estimates | Geography: Global
Note: This market size is based on global revenue from last-mile delivery services.

Figure 44. COMMON INDUSTRY KPIS

- Gross merchandise volume (GMV)
- Net revenue/GMV (take rate %)
- Ecommerce conversion rate
- Average order value (AOV)
- Customer lifetime value (LTV)
- Monthly active users (MAU)
- Market penetration %
- On-time delivery %

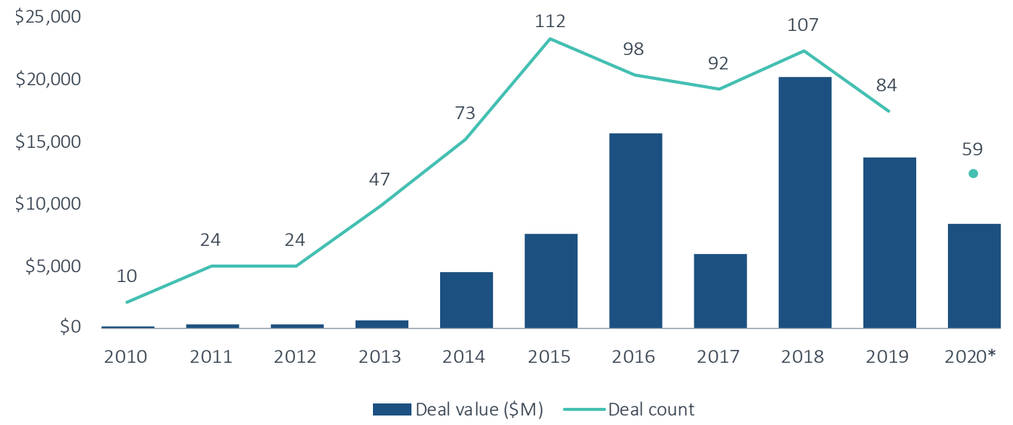
distributed to the couriers. Additionally, some platforms such as **Meituan** charge fees to restaurants for more favorable app placement.

VC activity

Last-mile delivery VC deal value has seen an upward trend over the past few years as delivery services rapidly expand in an underpenetrated market. Late-stage deals continue to dominate capital deployed to the segment, reflecting the relative maturity of VC-backed companies operating in the space. We expect the funding environment for delivery startups to be favorable relative to other mobility tech segments in the near to medium term.

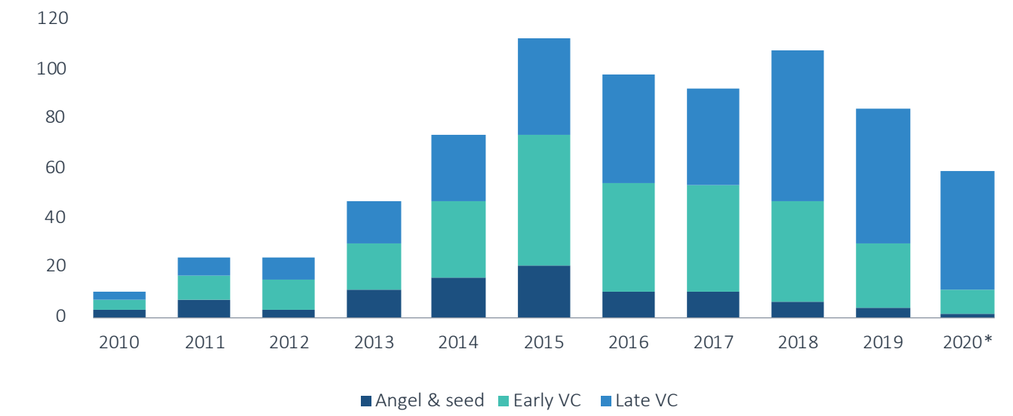
Through Q3, investors have funneled $8.4 billion across 59 deals. In Q3 alone, last-mile delivery companies raised $1.5 billion in venture funding, up 31.3% YoY but down 35.8% QoQ. Standout deals in the third quarter include **Miss Fresh**'s $495.0 million late-stage VC round in July, **Rappi**'s $300.0 million late-stage round in September, and **Grab**'s $200.0 million late-stage round in August.

Figure 45. LAST-MILE DELIVERY VC DEAL ACTIVITY



Source: PitchBook | Geography: Global | *As of September 30, 2020

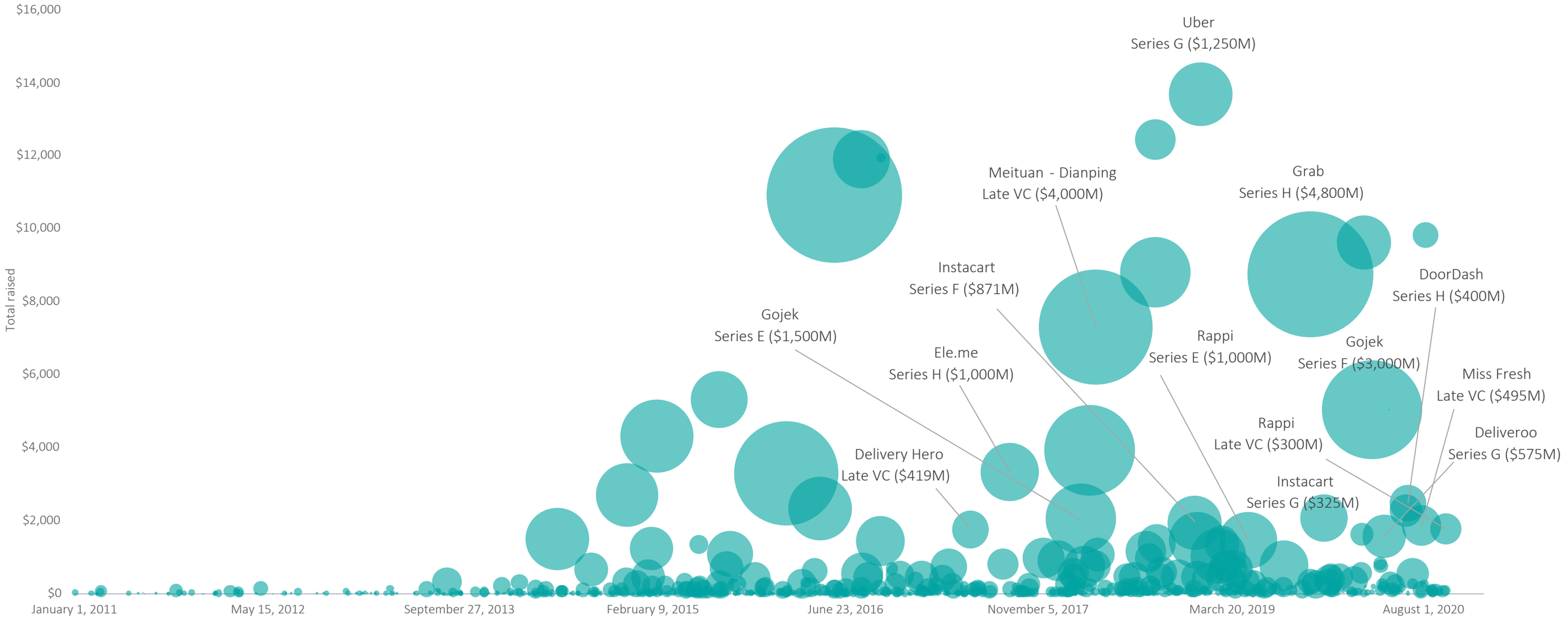
Figure 46. LAST-MILE DELIVERY VC DEALS (#) BY STAGE



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 47.

Last-mile delivery VC landscape ($M)



Source: PitchBook

Note: The left axis indicates total VC raised as of deal date. Bubbles indicate amount raised.

Figure 48.

Notable last-mile delivery VC deals

COMPANY NAME	CLOSE DATE	SUBSEGMENT	DEAL SIZE ($M)	POST-MONEY VALUATION ($M)*	DEAL STAGE	LEAD INVESTOR(S)
Miss Fresh	July 23, 2020	Delivery	$495.0	$3,500.0	Late-stage VC	CICC Capital
Rappi	September 24, 2020	Delivery	$300.0	$3,500.0	Late-stage VC	N/A
Grab	August 3, 2020	Ridesharing platforms, delivery	$200.0	N/A	Late-stage VC	STIC Investments
Misfits Market	July 22, 2020	Delivery	$85.0	N/A	Series B	Valor Equity Partners
Drizly	August 20, 2020	Delivery	$50.0	N/A	Series C	Avenir Growth Capital
Retrotope	August 28, 2020	Delivery	$50.0	$175.0	Late-stage VC	N/A
Volansi	September 15, 2020	Delivery	$49.4	$249.4	Series B	Icon Ventures

Source: PitchBook | *As of September 30, 2020

Figure 49.

Notable last-mile delivery VC exits

COMPANY NAME	CLOSE DATE	SUBSEGMENT	EXIT SIZE ($M)	POST-MONEY VALUATION ($M)*	EXIT TYPE	ACQUIRER(S)/INDEX
Woowa Brothers	April 13, 2020	Delivery	$4,000.0	$4,597.7	M&A	Delivery Hero
Dada-JD Daojia	June 5, 2020	Delivery	$3,235.8	$3,555.8	IPO	NASDAQ
Cornershop	July 1, 2020	Delivery	$459.0	$459.0	M&A	Uber

Source: PitchBook | *As of September 30, 2020

Figure 50.

Key VC- and PE-backed last-mile delivery companies

COMPANY NAME	TOTAL VC RAISED ($M)	SUBSEGMENT
Grab	$9,826.1	Ridesharing platforms, delivery
Gojek	$5,051.0	Ridesharing platforms, delivery
DoorDash	$2,471.7	Delivery
Instacart	$2,269.8	Delivery
Miss Fresh	$1,857.0	Delivery
Rappi	$1,764.3	Delivery
Swiggy	$1,621.5	Delivery
Deliveroo	$1,556.2	Delivery
Zomato	$823.3	Delivery
Yiguo	$800.0	Delivery
Hive Box Technology	$759.3	Delivery, logistics
GoPuff	$758.3	Delivery

Source: PitchBook | *As of September 30, 2020

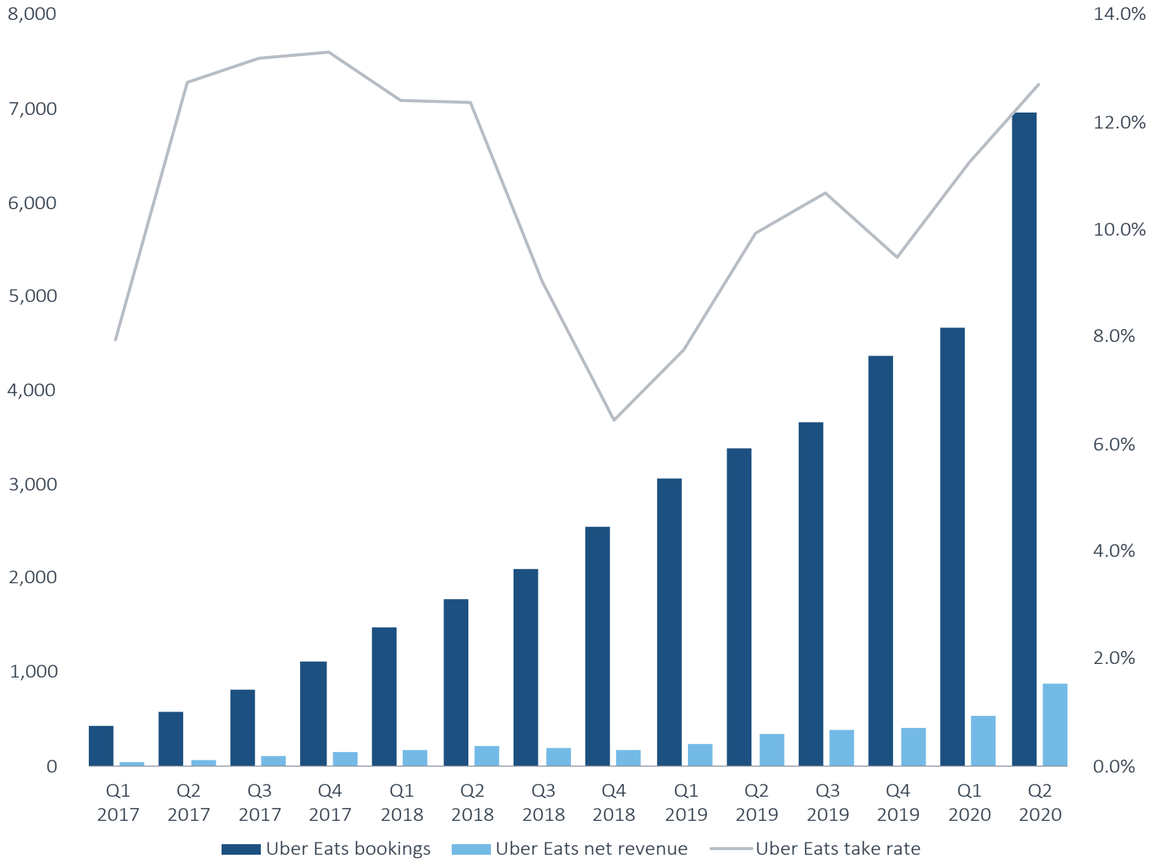
Opportunities

Food delivery: The rapid rise of food delivery platforms (e.g., **Grubhub**, **DoorDash**, and **Uber** Eats) has had a profound impact on the restaurant industry, with incumbent delivery-based companies such as pizza franchises feeling the pressure as more restaurants take share of the food delivery pie. According to **Uber**, the home food delivery market has grown at a CAGR of 77% since 2013, well above the growth rate of the consumer food service market.[10] In much the same way that ecommerce took share from physical retail, we believe food delivery may be taking share from traditional eat-in restaurants. According to the US Department of Agriculture, millennials place a greater preference for convenience when making food-related shopping purchases related to than other generational cohorts, leading to greater usage of delis, carry-out, fast food, and food delivery services.[11] We see food delivery as an attractive, mature market and are more positive on late-stage companies such as **DoorDash**, **Postmates**, **Instacart**, and **Deliveroo** relative to newer entrants, given their scale and capital advantages.

Combined mobility and food delivery platforms: Ridesharing companies are leveraging their platforms to provide food delivery services. While this includes **Uber** with its fast-growing **Uber** Eats service, we see continued opportunity for global ridesharing platforms **Grab**, **Careem**, and **Ola** to capture market share, and we expect more late-stage investment in these businesses. We see long-term benefits to the mobility-as-a-service strategy, as bundling services has the potential to expand the addressable market and create a source of competitive advantage relative to more pure-play applications. Similar

Figure 51.

Uber Eats bookings and revenue ($M)



Source: Uber and Lyft

10: "Form S-1 Registration Statement: Uber Technologies, Inc.," SEC, April 11, 2019
11: Food Purchase Decisions of Millennial Households Compared to Other Generations, US Department of Agriculture, Annemarie Kuhns and Michelle Saksena, December 2017

to how Amazon monetized its user base across several services (e.g., video, grocery, AWS, etc.), we believe ridesharing providers could replicate such platforms in the transportation world. This could allow providers to further leverage their existing driver networks and drive synergies by optimizing driver utilization between ridesharing and food delivery.

Delivery robots: Delivery robots have the potential to dramatically reduce costs across the delivery supply chain (e.g., wages for drivers and couriers) while also improving automobile energy efficiency and traffic congestion levels. Startups developing robots to capture this market include **Nuro**, **Postmates**, **Zume**, **Starship Technologies**, **Clearpath Robotics**, **Boxbot**, **Kiwibot**, and Marble. In addition, large incumbents such as Amazon and **FedEx** are developing their own in-house delivery robots.

Delivery drones: The use of drones for air delivery of smaller packages presents another alternative. Companies working on drone-enabled delivery include **Zipline** International, **Matternet**, **Flirtey**, and **Flytrex**. Although we see the largest market for drone delivery as serving ecommerce needs for residential areas, some drone-focused startups have found their niche targeting more underserved communities. Silicon Valley-based **Zipline** International utilizes a fleet of drones to deliver blood, plasma, and medicine to remote clinics in East Africa. While we believe autonomy and drone delivery could have significant potential, both technologies are likely to face significant regulatory hurdles and a long adoption curve as consumers adjust to these new experiences.

Delivery management software: Delivery management software helps inventory-heavy enterprises manage local deliveries and integrate with third-party carriers. Features include real-time dispatching, managing, and tracking of packages, establishing proof of delivery, and collecting signatures.

Some providers also enable enterprises to integrate with third-party delivery services such as UPS and **FedEx**. Delivery management software providers tend to target small and medium-sized businesses that seek to reduce time and cost associated with delivery, increase capacity, and improve the customer experience. Delivery management software providers include **GetSwift**, **MetaPack**, **Bringg**, **FarEye**, **WorkWave**, and **LogiNext**.

Considerations

Food delivery margins structurally low: Food delivery is a structurally low-margin business as services are relatively commoditized and undifferentiated. Customer incentives intended to expand market share further pressure profitability. For example, **Uber** Eats has a take-rate below its corporate average, reflecting the heavy use of incentives. Similarly, prior to its recent acquisition, **Grubhub** has seen margin pressure due to increased marketing spend and competitive pressure from companies such as **DoorDash** and **Uber** Eats. While the market for food delivery is large, consumer price sensitivity and the competitive landscape may permanently impede margin expansion, limiting returns for investors.

Large investment capital needed to grow market share: Food delivery startups need massive infusions of capital to grow and face heightened competition from incumbent ridesharing companies that already have greater scale and capital advantages. With food delivery commissions roughly half that of ridesharing, **Uber** has depended heavily on its higher-margin businesses along with outside funding to finance its aggressive expansion into food delivery. Similar to other companies in the space, **Uber** also relies on heavy subsidies and promotional activity, further pressuring margins. Other ridesharing companies that have moved into food delivery include **Grab**, **Careem**, and **Ola**.

Labor regulation and minimum wage rules: The last-mile delivery industry is facing increasing pressure from regulators. In late 2019 California signed AB 5 into law, entitling gig-economy workers to receive a minimum wage and greater labor protections. This makes it more difficult for food and grocery delivery services such as **Uber** Eats and **DoorDash** to classify their workers as independent contractors. Despite a potentially lengthy implementation, we expect this legislation to put negative pressure on last-mile delivery company margins as the industry likely will have to pay more to drivers. We believe driver wages are seeing upward pressure across the country and expect to see continued scrutiny surrounding labor practices.

Partner risk: After Amazon acquired Whole Foods, it eventually terminated the grocer's deal with **Instacart** to provide grocery delivery. Presumably, Amazon intends to provide Whole Foods delivery through its own app. This highlights the partner risk inherent to delivery services as the competitive interests of providers and retailers have the potential to become misaligned.

Autonomous last-mile delivery stalled by setbacks: Although deep learning has enabled material progress in autonomous driving, the technology still has its shortcomings. While deep learning is excellent at categorizing objects or scenarios it has seen, it struggles to contextualize objects and scenarios it hasn't categorized. For example, placing small stickers on a stop sign can sometimes cause an autonomous vehicle to fail to recognize the sign and consequently not stop.[12] We believe UK autonomous vehicle startup **Wayve** may have a novel approach to machine learning that could give it an edge in the market. Whereas large technology companies train vehicles by using rules, large datasets, and sophisticated sensory equipment, **Wayve** uses limited amounts of data with a greater focus on machine learning.

12: Robust Physical-World Attacks on Deep Learning Models," Kevin Eykholt, et. al., July 27, 2017

These kinds of novel approaches will be key to solving issues surrounding the limitations of deep learning technology and ultimately enabling commercialization.

Outlook

Social distancing to expand market: The coronavirus pandemic and subsequent stay-at-home orders have driven more demand for delivery services. We believe much of this demand is coming from first-time buyers that have not been previously exposed to these services. Chinese online grocery and food delivery apps **Dada**, **Meituan**, and **Ele.me** have reported major surges in demand as government-mandated quarantining measures went into effect. US food delivery providers such as **DoorDash**, **Uber** Eats, **Instacart**, and **Postmates** have seen a similar boost to sales, driven by an uptick in pandemic-induced demand.

Large M&A to continue to make industry viable: The North American restaurant delivery market has consolidated to three major players: **DoorDash**, **Uber** Eats-**Postmates**, and **Just Eat** Takeaway-**Grubhub**. We have long maintained that consolidation is necessary for the online food delivery industry to achieve sustainable margins. In 2019, **Uber** acquired grocery delivery startup **Cornershop**, and **DoorDash** acquired food delivery competitor **Caviar**. In early 2020, European competitors **Just Eat** and **Takeaway.com** finalized their merger. In June 2020, **Just Eat** Takeaway acquired **Grubhub** for $7.3 billion, and in July 2020, **Uber** announced an agreement to acquire **Postmates** for $2.7 billion.

New entrants to keep pressure on margins: While the **Uber** Eats-**Postmates** tie up could lead to more rational pricing, **Just Eat** Takeaway's entrance into the North American market could be a setback. **Grubhub** had been losing share due to its limited cash

availability to invest in expansion relative to **Uber** and **DoorDash**. If **Just Eat** Takeaway, a well-funded, outside competitor, gains a foothold in the North American market, the company could cut into **Uber** and **DoorDash**'s growth plans and potentially put downward pressure on pricing and margins in the space, delaying the industry's path to profitability.

Fees could come under pressure as restaurants struggle: Online food delivery platforms are facing scrutiny over restaurant fees that can range from 10% to 40% of gross transactions. Lawmakers across the US have proposed capping these fees to the 10%-15% range, which would likely put pressure on growth and margins. Several cities in California and New York have already mandated fee caps. Additionally, we expect lawmakers will continue to pass legislation limiting the use of contracted workers, another threat to margins to the extent drivers receive more pay.

Coronavirus could catalyze investment in autonomous delivery vehicles and drones: Prior to this crisis, investors and management teams primarily viewed autonomous delivery as a means to reduce delivery costs. The pandemic has revealed a new use case: increasing safety for consumers and helping providers ensure service continuity when human drivers may not be available. Startups that may benefit from this trend include autonomous robot providers **Nuro**, **Starship**, and **Refraction AI**; automated delivery van providers **Gatik**.AI and **Arrival**; and drone companies such as **Zipline**, **Flytrex**, and **Flirtey**. Autonomous delivery pilots that are underway include the partnership between CVS and **Nuro** for prescription deliveries in Houston, Texas in the US. CVS has also partnered with UPS Flight Forward, a drone-focused subsidiary of UPS working with drone startup **Matternet** to deliver medical supplies to retirement communities in Florida in the US. **Zipline** has begun leveraging its drone delivery technology, previously used in Africa, to provide personal protective equipment and essential medical supplies to US hospitals.

Grocery-focused delivery platforms could see uplift: We expect reduced restaurant traffic to provide a long-term uplift to the grocery industry. Key factors driving this shift include lower prices per quantity of food relative to restaurant orders, reduced movement of people into urban areas as more people work from home permanently, and improvement in grocery delivery and curbside pickup services, which hastens market adoption. Beneficiaries of this trend include delivery platforms focused on grocery and convenience items, such as **Instacart** and **GoPuff**. For more detail on the delivery technologies involved in the grocery industry, see our Q2 analyst note **Delivery Technologies Are Reshaping the Grocery Industry**.

Data will drive differentiation: Critics of ridesharing and food delivery claim consumers will opt for the lowest-priced option, yet we believe delivery and other mobility-oriented platforms can successfully differentiate themselves by leveraging user data to create curated experiences. For example, many companies are identifying demand for specific foods in certain neighborhoods (i.e., the rise of "cloud kitchens"). The ability to store payment, address, contact information, and order history also adds stickiness and can help drive network effects.

SEGMENT DEEP DIVE

Fleet management & connectivity

Overview

Fleet management & connectivity solutions providers connect vehicles to people, networks, and infrastructure. This segment includes connectivity and data management platforms, fleet management platforms and tools, parking applications, passenger safety tools, and automotive cybersecurity technology.

Connectivity & data management: Companies in this subsector seek to build platforms and tools that enable cars to communicate bidirectionally with other systems. Companies such as Autonomic and **Wejo** are developing connected car platforms to serve as operating systems for mobility, while others provide software tools that enable collection, sharing, and management of data.

Fleet management: Companies in this subsector provide mobile workforce platforms and solutions for service-based businesses operating fleets (e.g., UPS, long-haul trucking). Services include tracking, routing, scheduling, and monitoring fuel consumption and driver behavior. Providers can also help ensure compliance with policies, monitor diagnostics, document damages, update inspections, and schedule repairs and service.

Industry drivers

Demand for better in-car information systems: Potential consumer benefits of connected cars include uninterrupted access to cloud services, information channels that create a unified experience, and the ability to provide information to drivers, such as delays and safety hazards.

Need for systems to connect autonomous vehicles: As self-driving technology matures, the need for unified systems that can connect autonomous vehicles is growing. Dozens of companies, many backed by OEMs, are competing to provide the next generation of operating systems for mobility.

Demand for improved fleet efficiencies: Emerging technologies that enable better monitoring of vehicles and drivers are critical to fleet management. Monitoring technologies enable commercial fleet operators to improve efficiencies, track expenses, and reduce the risks inherent to vehicle investment.

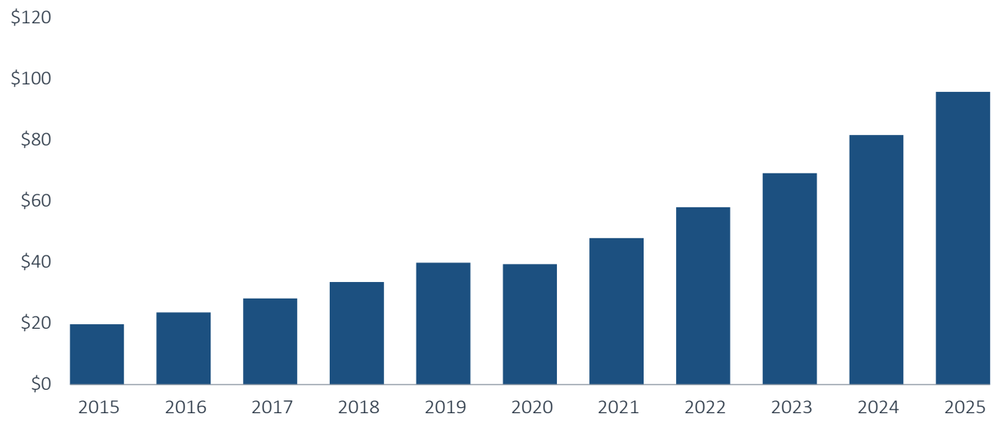
Market size

We estimate the current global connected car market—which includes sales of fleet telematics solutions as well as driver assistance, safety, entertainment, and automotive cybersecurity technology—as reaching approximately $39.9 billion in 2019. We expect this market to grow to $95.8 billion in 2025, driven by increased adoption of these technologies. We do not include advanced driver-assistance systems in our forecast. We believe this sector will be moderately affected in 2020 by the pandemic-induced crisis but view the segment as relatively well positioned.

Business model

Fleet management solutions generally charge subscription fees for SaaS solutions or other transactional services often paired with in-vehicle monitoring hardware. Connectivity suppliers monetize by providing systems and components to major original equipment manufacturers.

Figure 52. FLEET MANAGEMENT & CONNECTIVITY MARKET SIZE ($B)



Source: Pitchbook estimates, BERG Insights, and Fleetmatics | Geography: Global

Figure 53. COMMON INDUSTRY KPIS

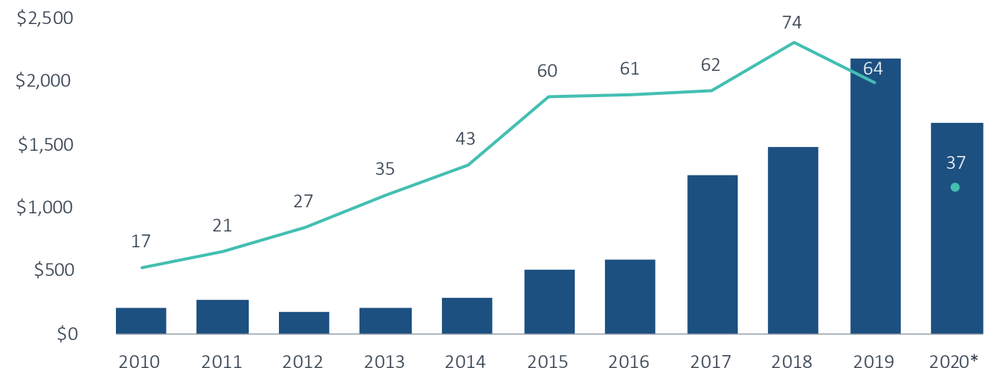
- Fleet size
- Price per subscription
- Additional features
- Revenue by sales channel
- Data volume
- Threat detection
- Time to market

VC activity

Investment into the fleet management space has generally seen an upward trend over the past few years. VCs pursuing deals in this industry have primarily concentrated capital in late-stage companies, reflecting the maturity of companies operating within the space. We expect investment into fleet management & connectivity solutions to remain strong over the next few quarters.

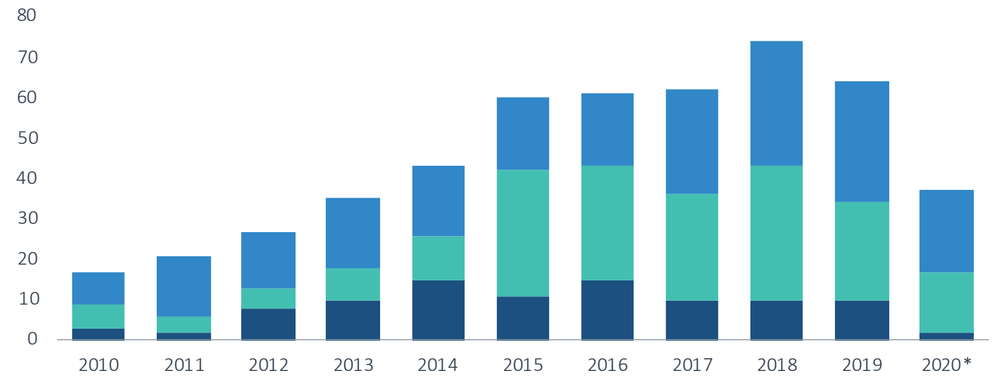
Fleet management & connectivity companies raised $333.8 million in venture funding in Q3 2020, down 68.5% QoQ and 15.8% YoY. Despite the quarter's decline, aggregate funding for the sector has been strong in the year. In the first three quarters of 2020, fleet management & connectivity companies have raised $1.7 billion, putting the sector on pace to eclipse 2019's record of $2.2 billion. Top deals in the quarter include **Kymeta**'s $215.0 million Series B1 round in August, **FarEye**'s $37.5 million Series D round in August, and **Aurora** Lab's $23.0 million Series B in September.

Figure 54. FLEET MANAGEMENT & CONNECTIVITY VC DEAL ACTIVITY



Source: PitchBook | Geography: Global | *As of September 30, 2020

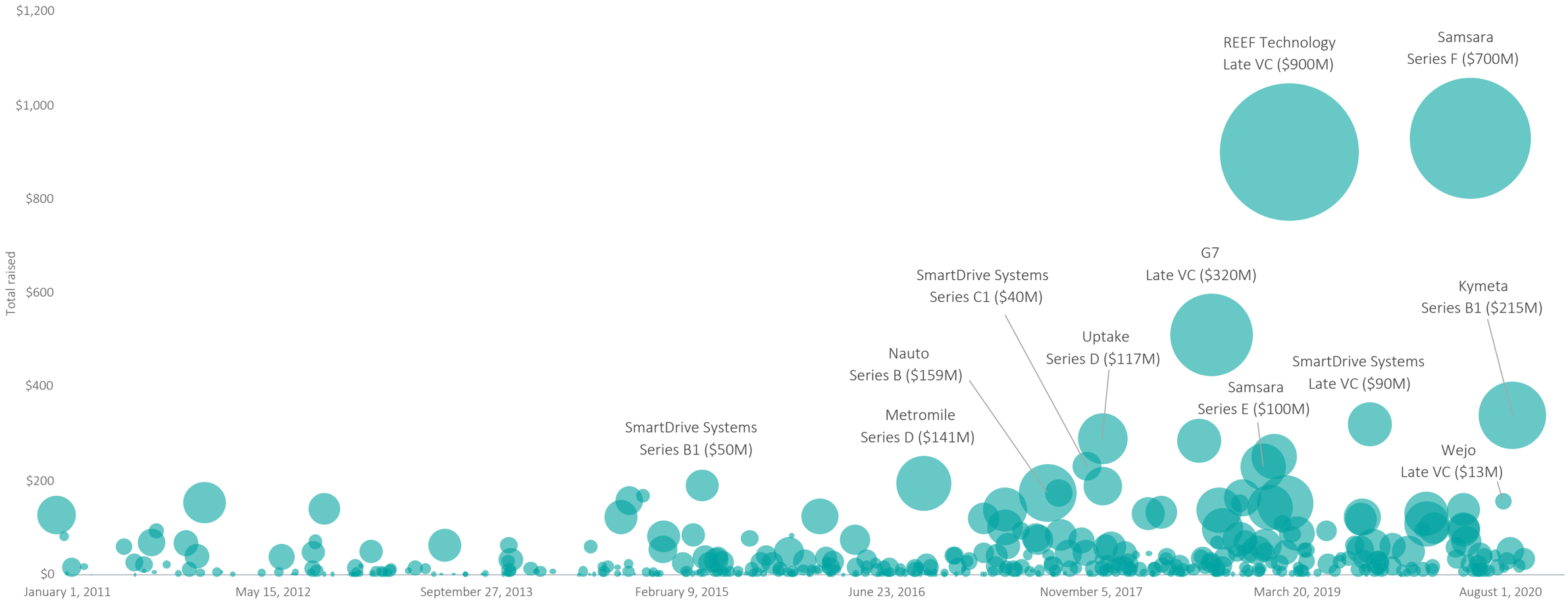
Figure 55. FLEET MANAGEMENT & CONNECTIVITY VC DEALS (#) BY STAGE



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 56.

Fleet management & connectivity VC landscape ($M)



Source: PitchBook

Note: The left axis indicates total VC raised as of deal date. Bubbles indicate amount raised.

Figure 57.

Notable fleet management & connectivity VC deals

COMPANY NAME	CLOSE DATE	SUBSEGMENT	DEAL SIZE ($M)	POST-MONEY VALUATION ($M)*	DEAL STAGE	LEAD INVESTOR(S)
Kymeta	August 25, 2020	V2X, connectivity & data management	$215.0	$375.0	Series B1	Doug Hutcheson, William Gates
FarEye	August 21, 2020	Fleet management, delivery	$37.5	N/A	Series D	M12, The Fundamentum Partnership
Aurora Labs	September 22, 2020	Connectivity & data management	$23.0	N/A	Series B	LG Technology Ventures, Marius Nacht
AiDriving	August 13, 2020	Fleet management	$14.4	N/A	Series C	N/A
Wejo	August 3, 2020	Connectivity & data management	$12.7	N/A	Late-stage VC	DIP Capital
Sibros	July 20, 2020	Connectivity & data management	$12.0	$60.0	Series A	Nexus Venture Partners

Source: PitchBook | *As of September 30, 2020

Figure 58.

Notable fleet management & connectivity VC exits

COMPANY NAME	CLOSE DATE	SUBSEGMENT	EXIT SIZE ($M)	POST-MONEY VALUATION ($M)*	EXIT TYPE	ACQUIRER(S)/INDEX
Fleetonomy	September 1, 2020	Fleet management	N/A	N/A	M&A	Via
Moovit	May 4, 2020	Smart transit, connectivity & data management	$900.0	$900.0	M&A	Intel
Owlcam	March 3, 2020	Passenger safety	N/A	N/A	Buyout/LBO	Capitala Group, Hammond, Kennedy, Whitney & Company, Xirgo Technologies
Drivemode	September 26, 2019	Fleet management	N/A	N/A	M&A	**Honda** Motor Company

Source: PitchBook | *As of September 30, 2020

Figure 59.

Key VC & PE-backed fleet management & connectivity companies

COMPANY NAME	TOTAL VC RAISED ($M)	SUBSEGMENT
Samsara	$930.0	Fleet management
REEF Technology	$900.0	Parking
G7	$510.0	Fleet management
Kymeta	$339.0	V2X, connectivity & data management
SmartDrive Systems	$320.5	Fleet management
Uptake	$290.0	Fleet management
Metromile	$285.2	Connectivity & data management
AutoAI	$252.5	Fleet management
Nauto	$174.2	Fleet management
Inrix	$168.0	Connectivity & data management
Valens	$164.0	V2X, connectivity & data management
Wejo	$156.7	Connectivity & data management

Source: PitchBook | *As of September 30, 2020

Opportunities

Advanced fleet management: Emerging fleet management platforms provide tools designed to improve shipping speeds, reduce downtime, and enhance service outcomes across the supply chain. Full-service, cloud-hosted fleet management platforms such as **G7** and **Samsara** can provide actionable business intelligence that can enhance routing and dispatch capabilities, reduce fuel use, and improve safety. Integration capabilities with existing back-end systems represent a key differentiator among providers.

Driver monitoring & predictive analytics: The fleet management industry has expanded its focus from tracking and vehicle positioning (i.e., fuel and routing efficiency) to camera-based platforms that monitor driver behavior. These products can help reduce distractions and collisions, as well as other behaviors, such as hard braking, which reduces fuel economy.[13] With over 100 million commercial vehicles on the road today, we see a long runway of growth for driver monitoring providers.

We believe driver monitoring platforms that utilize predictive analytics are best positioned to succeed. These solutions typically pair cameras with a predictive analytics platform to flag problematic behaviors, such as distracted and drowsy driving, speeding, and tailgating. Predictive analytics enable fleet operators to improve driver training, incentivize better driving, and potentially avert incidents before they occur. Notable commercial fleet-focused driver monitoring providers include **SmartDrive** Systems, which focuses on general commercial fleets, including trucks, buses, and rail; **Nauto**, which is workforce focused, recording incidents and generating a driver "score" through an automated process; and **NetraDyne**, which provides positive reinforcement to drivers for hitting milestones, such as miles driven within lane markings.

Passenger safety: In addition to perception-based driver assistance systems, we expect automakers to invest in technologies that improve passenger safety. Driver and passenger monitoring tools have important consumer safety applications. Startups **Guardian Optical Technologies** and **Eyeris** use cameras and other sensors to detect smartphone use, eyelid closure, head positioning, and other factors. These solutions also monitor passengers for distress indicators and scan for children accidently left in back seats. **Neteera** uses a sub-terahertz (THz) imaging camera to detect electromagnetic emissions from sweat ducts to identify stress levels and alcohol levels. **Nexar** leverages machine learning to monitor road safety and can connect to emergency services. This information is then combined with vehicle telemetry, weather, and traffic reports to provide hazard warnings for drivers and cyclists. **Affectiva** scans passenger faces to analyze for emotional responses. Startup **Simpler Studios** trains its predictive analytics and machine learning models on a nationwide database of accident data to identify crash hotspots. Additional companies in the camera-based emotion reading space include EmotionReader, Kairos, Realeyes, nViso, and **Aurora** Computer Services.

Insurance underwriting data: Comprehensive driver data helps insurers underwrite risk and can potentially cut premiums and loss ratios. Large insurance providers such as State Farm and Progressive are increasingly offering telematics solutions in exchange for potentially lowered rates. Mobile-based solutions such as Root Insurance and **Zendrive** enable rate adjustment based on behavioral metrics such as phone use and heavy braking. Startup **Tnedicca** helps auto insurers determine individual risk profiles based on route-specific exposure to traffic crash hotspots. **Tesla** also recently announced a car insurance offering; the company is well positioned to leverage its unique over-the-air capabilities and in-car camera network to build comprehensive risk models.

13: "How to Maximize Fuel Economy," AAA, n.d.

Predictive maintenance: Predictive maintenance platforms leverage AI & ML to reduce breakdowns and fuel costs. We believe the market for predictive maintenance for fleet management is approximately $60 million today and expect it to grow to $945 million by 2030. Emerging providers include **FleetPal** and **Stratio**. **Uptake**, a leader in the space, provides a SaaS-based product that monitors engine performance data on an ongoing basis to proactively flag issues. These services can shorten downtime while also improving vehicle utilization.

Monetization of data: According to Dell EMC and Altran, the average autonomous vehicle can produce at 30-80 TB of data per day.[14] A significant growth opportunity may exist in data management and the potential monetization of this data in unique ways. For example, a weather-tracking tool could benefit from having up-to-date temperature and atmospheric pressure data from thousands of data points across a city. Startups in this space include **Airbiquity**—which focuses on over-the-air software updates to vehicles, enabling cost savings for automakers and fleet operators—and mobility network platforms such as Otomono, which builds rich datasets from information gathered by autonomous vehicle sensors, such as mapping data, and sells it to third parties.

Automotive cybersecurity: We see a large scope for auto-cybersecurity and note the definition according to the National Highway Traffic Safety Administration, an agency of the US federal government, which includes protection of "automotive electronic systems, communication networks, control algorithms, software, users, and underlying data" from "malicious attacks, damage, unauthorized access, or manipulation."[15] Researchers recently demonstrated the vulnerabilities of a Jeep Cherokee by taking control of it remotely, leading to a 1.4 million vehicle recall by FCA. Key VC-backed companies in this space include **Mocana**, Guardknox, **Trillium Secure**, **Excelfore**, and Upstream.

14: Dell EMC Isilon: Storage Solution for Autonomous Driving, Dell-EMC, July 2019
15: "Overview: Automotive Cybersecurity," National Highway Traffic Safety Administration, United States Department of Transportation, n.d.

Considerations

Fleet management incumbents will be hard to unseat: Fleet management is dominated by large, consolidated companies. **Verizon** is the dominant player in this market, having acquired Networkfleet, Telogis, and Fleetmatics in recent years and rolled them into Verizon Connect. According to Berg Insights, other players in the space include startups **Trimble**, Geotab, and Omnitracs in North America; TomTom Telematics (acquired by Bridgestone for $1 billion), **Masternaut** (acquired by Michelin), and **Transics International** in Europe; and E6GPS and Etrans in China. Automotive manufacturers have also entered the market by offering integrated solutions for commercial fleet vehicles. Although venture-backed companies are well funded, incumbents' scale advantages will make it difficult for new entrants to compete. Larger fleet management companies can generally provide superior service and underprice local competitors. Still, with most of the commercial fleet market untapped, we see a large opportunity for growth.

Uncertainty related to regulation: Regulation of connected and autonomous vehicles will likely play a crucial role in shaping how suppliers serve this industry. We believe safety- and security-focused companies within this segment are well positioned to benefit from future regulations, specifically for things related to cybersecurity and passenger safety. Venture-backed companies in this space include **WayRay**, **eyeSight**, **Nexar**, and **Smart Eye**. On the other hand, companies focused on data monetization, such as **Otonomo**, could see headwinds from potential data-privacy regulation.

Outlook

Segment relatively insulated from recession: We see relatively low risk associated with automakers and fleet operators reducing spending on connectivity and telematics solutions during the current crisis. In many cases, connected vehicle technology diminishes cost for carmakers. For example, sending over-the-air software updates is much more economical than updating vehicles through traditional dealer networks.

Similarly, we believe commercial fleet management tools are unlikely to see a substantial pullback in revenue. Fleet management technology tends to be a small portion of overall costs for fleet providers, especially compared with wages, fuel, depreciation, and maintenance. Moreover, many of these technologies help fleet operators lessen cost in the form of downtime. Limiting vehicle downtime is a huge value-add for commercial fleets, especially in the heavy trucking industry where a single failure point—be it a distracted driver or a faulty alternator—can be the difference between success and failure for the business. Predictive analytics platforms can generate favorable ROIs for fleet operators and help streamline businesses and contract fleet sizes by 10%-30%. During this period of recession, we expect continued growth from providers that enable shippers and operators to gain additional visibility into the movement of essential goods along freight channels.

Monitoring platforms will increasingly partner with insurers: We think winners in the driver monitoring space will be those that partner with large insurers. Progressive and Nationwide currently offer discounts to commercial fleet operators for installing video cameras. In addition to helping insurance companies reduce claims and payouts, winning products will be easy to use and integrate with existing workforce platforms and telematics software. Monitoring platforms could be attractive acquisition targets for large insurers going forward.

SEGMENT DEEP DIVE

Electric vehicles

Overview

Electric vehicles are vehicles (primarily passenger cars) that utilize electric motors to enable propulsion. The electric vehicles segment includes both manufacturers of electric vehicle platforms and providers of electric vehicle technology.

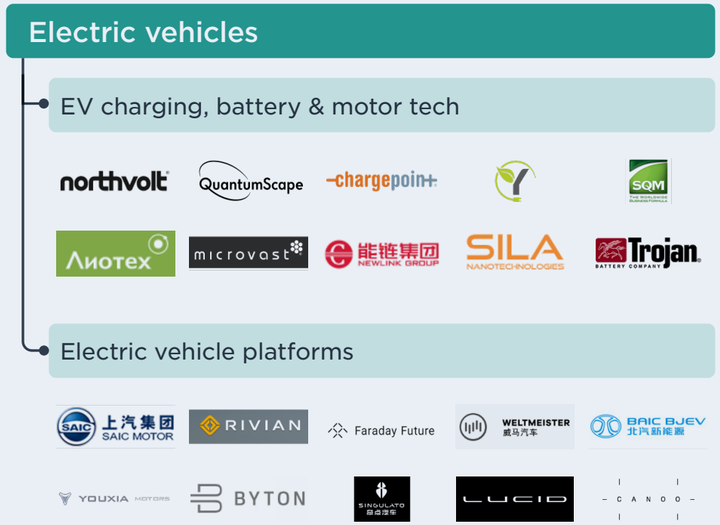
Electric vehicle platforms: Companies developing and manufacturing electric vehicles, powertrains, and platforms.

Electric vehicle charging, battery & motor technology: Companies manufacturing electric vehicle components, battery technology, and charging networks.

Industry drivers

Ongoing OEM investment: Major OEMs are increasing investments into electrification and electric vehicle platforms. Automakers such as **GM**, **Ford**, VW, and **Hyundai** have announced plans to invest billions into electrification over the next five years. Many other automakers, including **BMW**, Mercedes-Benz, Porsche, Mini, and Volvo—brands that have until now been relatively quiet in the electric vehicle space—have announced their own electric vehicle models expected to launch in the early 2020s.

Declining prices and affordability: As electric cars continue to become more affordable, we expect the technology to capture an increasing portion of the global new car sales market. Lithium and battery costs have generally declined over the past few years, enabling more affordable electric vehicle models to hit the market. Relative to internal combustion engine (ICE) vehicles, electric cars tend to have lower maintenance costs (i.e., no fuel and fewer moving parts), further improving affordability.

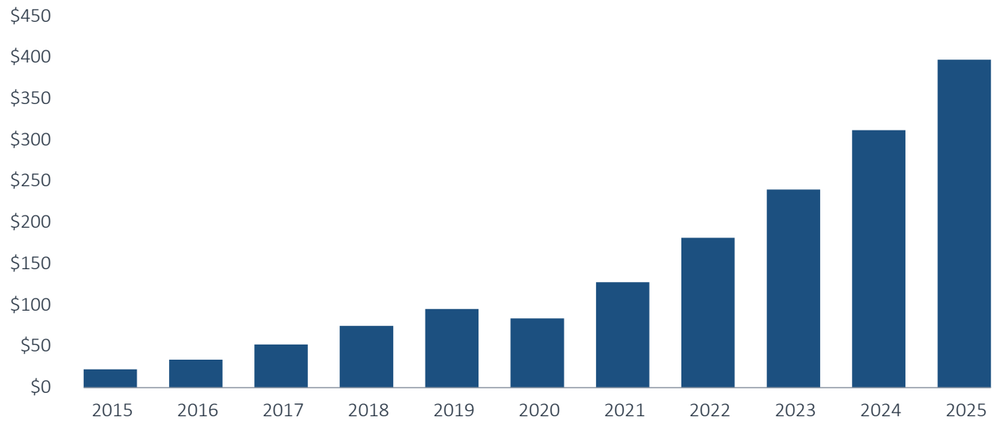


Favorable regulation: Countries and municipalities are increasingly introducing rules to curb emissions from gasoline and diesel-powered vehicles while providing subsidies to encourage electric vehicle sales. China, Denmark, France, India, Israel, Norway, the UK, and Sweden have made soft commitments to phasing out new gasoline and diesel vehicle sales by the 2030-2040 timeframe. Municipalities are moving more quickly, with cities including Amsterdam, Brussels, Los Angeles, London, Madrid, Paris, Rome, and Vancouver making soft commitments to phase out gasoline and diesel vehicles by the 2025-2030 timeframe. In September 2020, California's governor signed an order banning sales of new gasoline cars by 2035. The New York State Senate introduced a similar bill requiring new cars and trucks to be zero-emissions by 2035.

Market size

We expect the total market for plug-in hybrid and battery-powered electric vehicles to expand dramatically by the mid-2020s, from $95 billion in 2019 to $398 billion in 2025, driven by further market penetration of electric vehicles to 11.7% of new vehicle sales in 2025, up from 2.4% in 2019. We model a sales decline of 12% YoY in 2020, driven by the coronavirus pandemic. Although new electric vehicle sales will likely face near-term pressure, we expect them to bounce back in 2021 and the following years, propelled by global government incentives for clean energy investment and additional electric vehicle subsidies. In the long term, lower oil prices could affect the relative affordability of electric vehicles, even as battery manufacturing costs decline.

Figure 60. ELECTRIC VEHICLES MARKET SIZE ($B)



Source: Bloomberg New Energy Finance, internal PitchBook estimates | Geography: Global
Note: Refers to sales of passenger electric vehicles.

Figure 61. COMMON INDUSTRY KPIS

- Vehicle deliveries
- Production levels
- OEM/Tier-1 partnerships
- MSRP relative to in-class electric vehicle and ICE vehicles
- Range
- Battery cycle life
- Battery efficiency
- Battery energy density
- Availability/utilization of charging infrastructure
- Smart features

Business model

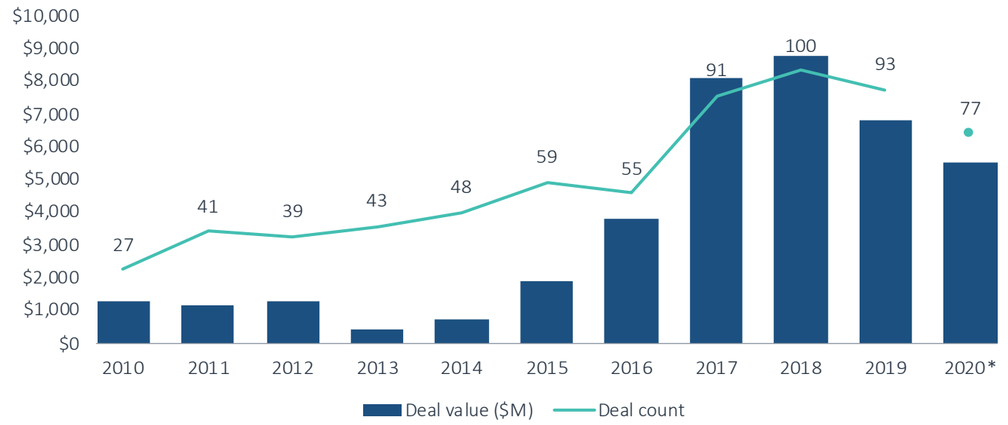
Companies within this segment manufacture and sell electric vehicles, powertrains and components, battery technology, and charging networks, all of which enable wider adoption of electric vehicles. They primarily compete with incumbent automakers and suppliers.

VC activity

Electric vehicle startups raised a staggering $3.9 billion in Q3 2020, up 279.8% QoQ and 67.0% YoY, driven by strong private and public investor enthusiasm for the electrification of transportation through adoption of battery-electric vehicle technology. Standout deals include **Weltmeister**'s $1.5 billion Series D in September, **Northvolt**'s $600.0 million early-stage VC round in September, and **Xpeng**'s $500.0 million Series C1 in July.

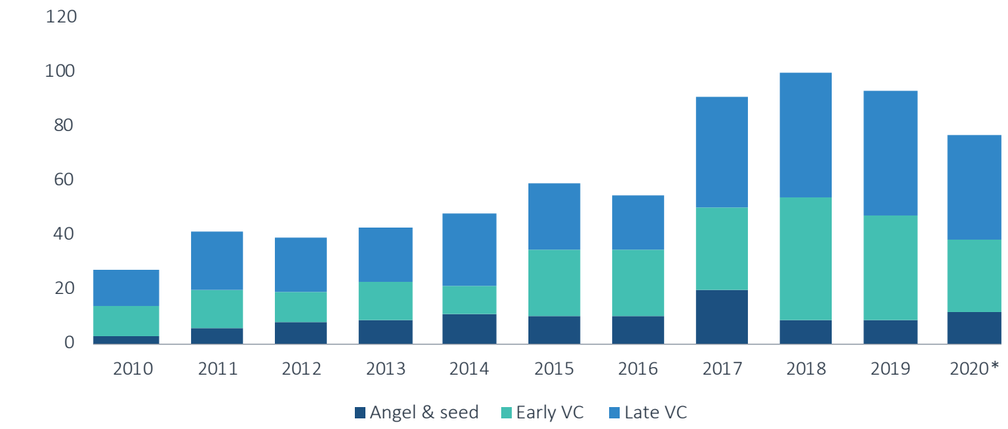
Though not included in these datasets, internal R&D and corporate investment drive much of the capital invested into the space. In 2019, GM and LG Chemical announced a $2.3 billion joint venture to build a $2.3 billion battery plant in in the US. In March 2020, GM announced that it plans to spend $20.0 billion on electric and self-driving vehicles through 2025. In February 2020, **Hyundai** Motor Group announced its plan to invest $87.0 billion into electric vehicle technology through 2025. Several electric vehicle startups including **Canoo**, Chargepoint, **Faraday Future**, **Fisker** Inc, **Hyliion**, **Lordstown Motors**, Nikola Motors, **QuantumScape**, Romeo Power, and **XL Fleet** have debuted or announced plans to debut on public markets through SPACs, representing over $6 billion invested in 2020 so far. Because they offer quicker time to market and less scrutiny, SPACs are an attractive listing option for electric vehicles companies and, more broadly, startups that are highly capital intensive and in the pre- to early revenue stages.

Figure 62. ELECTRIC VEHICLES VC DEAL ACTIVITY



Source: PitchBook | Geography: Global | *As of September 30, 2020

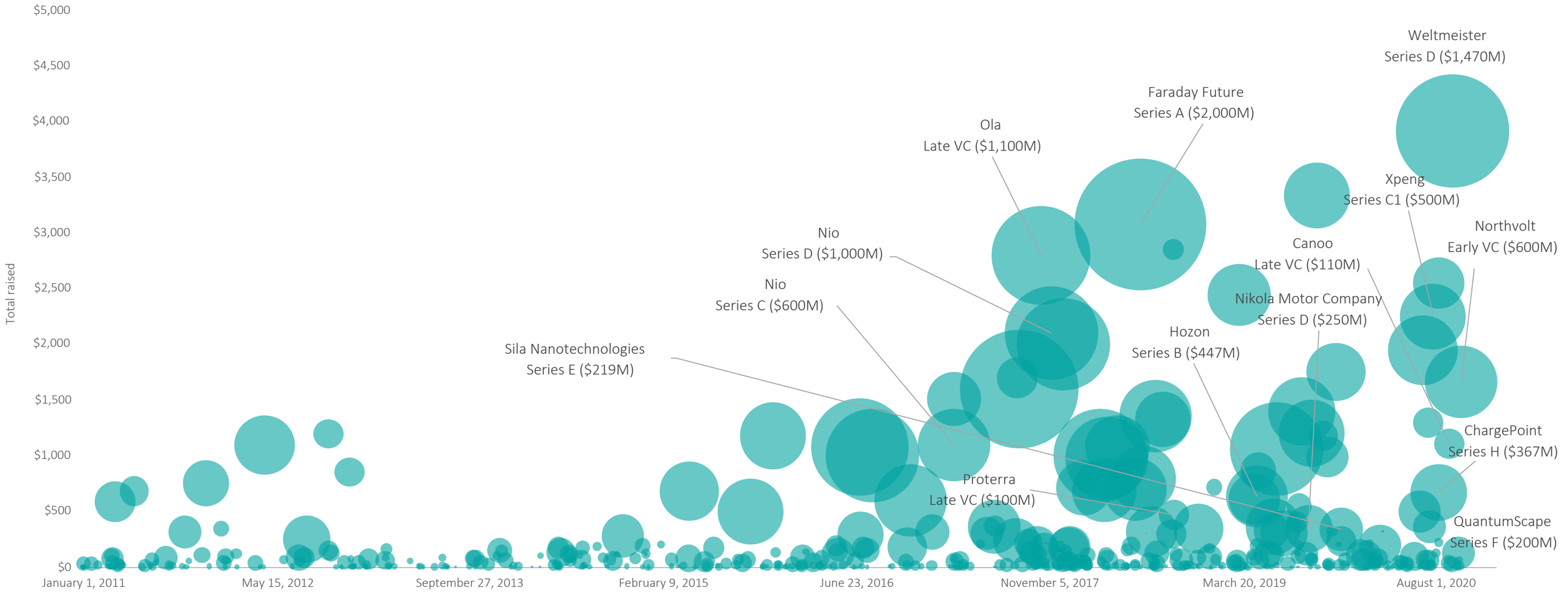
Figure 63. ELECTRIC VEHICLES VC DEALS (#) BY STAGE



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 64.

Electric vehicles VC landscape ($M)



Source: PitchBook

Note: The left axis indicates total VC raised as of deal date. Bubbles indicate amount raised.

Figure 65.

Notable electric vehicles VC deals

COMPANY NAME	CLOSE DATE	SUBSEGMENT	DEAL SIZE ($M)	POST-MONEY VALUATION ($M)*	DEAL STAGE	LEAD INVESTOR(S)
Weltmeister	September 9, 2020	Electric vehicle platforms	$1,470.0	N/A	Series D	Shanghai International Group, SAIC Capital China
Northvolt	September 29, 2020	Electric vehicle charging, battery & motor tech	$600.0	N/A	Early-stage VC	Goldman Sachs Merchant Banking Division, Volkswagen, Baillie Gifford
Xpeng	July 20, 2020	Electric vehicle platforms	$500.0	N/A	Series C1	N/A
ChargePoint	August 5, 2020	Electric vehicle charging, battery & motor tech	$367.3	$1,367.3	Series H	Satif Group
Xpeng	August 3, 2020	Electric vehicle platforms	$300.0	N/A	Series C2	Alibaba Group
NewLink Group	July 10, 2020	Electric vehicle charging, battery & motor tech	$127.3	N/A	Series D	CICC Capital
Star Charge	September 24, 2020	Electric vehicle charging, battery & motor tech	$125.1	$1,200.1	Series A	Schneider Electric China Investment, CICC Capital
Canoo	August 31, 2020	Electric vehicle platforms	$110.0	N/A	Corporate	N/A

Source: PitchBook | *As of September 30, 2020

Figure 66.

Notable electric vehicles VC exits

COMPANY NAME	CLOSE DATE	SUBSEGMENT	EXIT SIZE ($M)	POST-MONEY VALUATION ($M)*	EXIT TYPE	ACQUIRER(S)/INDEX
Xpeng	August 27, 2020	Electric vehicle platforms	$9,300.1	$10,796.1	IPO	New York Stock Exchange
Li Auto	July 30, 2020	Electric vehicle platforms	$8,525.5	$9,618.0	IPO	NASDAQ

Source: PitchBook | *As of September 30, 2020

Figure 67.

Key VC-backed electric vehicle companies

COMPANY NAME	TOTAL VC RAISED ($M)	SUBSEGMENT
Rivian Automotive	$6,001.3	Electric vehicle platforms
Faraday Future	$3,080.0	Electric vehicle platforms
Northvolt	$1,660.1	Electric vehicle charging, battery & motor tech
Karma Automotive	$1,297.4	Electric vehicle platforms
Canoo	$1,110.0	Electric vehicle platforms
ChargePoint	$671.9	Electric vehicle charging, battery & motor tech
Proterra	$545.0	Electric vehicle platforms, smart transit
QuantumScape	$496.3	Electric vehicle charging, battery & motor tech
Sila Nanotechnologies	$343.5	Electric vehicle charging, battery & motor tech
Ninebot	$180.0	Vehicle suppliers, electric vehicle platforms
StoreDot	$156.3	Electric vehicle charging, battery & motor tech
Lucid Motors	$131.1	Electric vehicle platforms

Source: PitchBook | *As of September 30, 2020

Opportunities

Electric vehicles: The success of **Tesla** has highlighted the demand for electric vehicles and major automakers such as GM, Nissan, and **Toyota**, as well as several VC-funded startups currently developing models. Key startups building electric cars include **Rivian**, NIO, **Canoo**, **Arrival**, **Faraday Future**, **Karma Automotive**, **Xpeng**, **Weltmeister**, BAIC Group, **CHJ Automotive**, **Fisker**, **Byton**, and **Leapmotor**. Nikola, Hyllion and Hyzon Motors (backed by Total) are developing hydrogen fuel cell trucks to compete with the **Tesla** Semi. not venture-backed, **Rivian**, **Lordstown Motors**, and **Bollinger Motors** are key new entrants to the electric pickup market.

Electric vehicle platforms: Unlike internal combustion engines, electric powertrains are small, have few moving pieces, and can be easily integrated into platforms that underpin multiple car designs, reducing the per-vehicle cost of manufacturing. These platforms consist of skateboard-shaped, chassis-housing battery packs, motors, driveline, suspension components, wheels, and braking systems—all the building blocks for driving. OEMs such as **Tesla**, **Ford**, and GM have developed their own proprietary skateboard platforms. **Toyota** and Subaru plan to collaborate on a shared all-wheel-drive electric vehicle platform. **Hyundai** has announced a partnership with Silicon Valley-based startup **Canoo**, which offers a modular vehicle system designed to accommodate various vehicle shapes beyond passenger vehicles, as well as a partnership with electric vehicle van company **Arrival**. Startups offering similar platforms include **Rivian**, which has partnered with **Ford**, and AEV Robotics. We expect the utility of these platforms to increase as they are used to build numerous products, such as ridesharing shuttles, food delivery pods, and logistics machinery.

Large and growing China opportunity: A significant number of key electric vehicle manufacturers including **Weltmeister**, NIO (NYSE: NIO), **Byton**, and Seres are either based in or backed by China. According to JP Morgan, the country could account for 55% of global sales by 2025, driven by increased affordability, rapid deployment of charging facilities, and additional subsidies and policies encouraging electric vehicle adoption.[16] The Chinese government is seeking to curb emissions by aggressively financing electrification startups in the region, and over 300 electric vehicle companies have registered for subsidies. Manufacturers in China do not pay import tariffs, and this represents a key cost advantage for providers attempting to break into the market.

Electrification of buses: China is also the leader in the electrification of buses. According to a BloombergNEF report, of the nearly 425,000 electric buses in the world, 421,000 are in China.[17] Electric buses, which operate in dense urban locations with much higher utilizations compared to passenger vehicles, have an outsized impact on the reduction of greenhouse gas emissions and noise pollution. AMPLY Power estimates that cities could save an average of 37% on fueling costs by switching to electric buses.[18] Key companies operating in the space include **BYD Company**, **Proterra**, and **Vantage Power**.

16: “Driving into 2025: The Future of Electric Vehicles,” JP Morgan, October 10, 2018
17: “China Set to Dominate Electric Vehicle Battleground for Decades,” BloombergNEF, with assistance by Ying Tian and Adrian Leung, May 15, 2019
18: "Understanding Electric Vehicle Fueling Costs Compared to Gasoline for Fleets," AMPLY Power, 2019

ELECTRIC VEHICLES

Electrification of freight: We believe the use of medium-size and heavy electric trucks could increase 15 times over by 2025 as favorable operating economics drive adoption. Relative to traditional diesel-powered trucks, electric trucks offer several benefits including: reduced fuel costs, up to 20% lower maintenance costs (given fewer moving parts to service),[19] less specialized equipment and labor needs, longer warrantied lifetimes, and steadily declining battery costs. Key companies developing truck electrification technology include **Tesla**, Nikola, **Hyliion**, Hyzon Motors, **Wrightspeed Powertrains**, **VIA**, and XOS Trucks (formally Thor Trucks). Notably, in June 2020 US state California announced that it will require all new trucks sold in the state to be zero-emissions. Whereas some providers are focusing on battery electric powertrains, others such as Nikola, **Hyliion**, and Hyzon Motors are focusing their efforts on developing hydrogen-fuel cell based powertrains. It remains to be seen how competitive fuel cell technology will be in electrifying freight compared to battery electric options. Barriers to hydrogen fuel cell adoption include the necessity of highly capital-intensive infrastructure rollouts. Nevertheless, the technology is more compelling that battery electric for heavy freight applications due to inherent technical advantages related to energy density.

Next-generation battery technology: We believe the long-term growth of electric vehicles will drive opportunities to invest in next-generation battery technology. As the world shifts to electric vehicles, automakers' roles are rapidly changing. Many providers are taking more control over their supply chains and battery technology, which drives the value proposition of cars much more than internal combustion engines have in the past. Key startups developing next-generation battery technology include **Enevate**, **Sila Nanotechnologies**, **Nexeon**, and Quantum Scape. Companies such as **Enevate** and **Sila Nanotechnologies** are developing next-generation lithium-ion batteries with silicon anodes instead of graphite anodes. These technologies should significantly improve electric vehicle range, safety, and charge times to the extent that recharging at a charge station could become as fast and easy as refilling gas. Relative to other startups in the space, we believe **Enevate** is well positioned because its business model is based on licensing technology rather than supplying materials. We view its relatively capital-light approach as a strong insulator during a sustained downturn.

Charging infrastructure benefits from fleet electrification: We see fleet electrification as a key growth driver for electric vehicle charging companies over the next 10 years. The vast majority of existing charging systems in the US are intended for consumer use, not commercial fleets. Assuming a fifteenfold increase in the global number of medium and heavy electric trucks on the road by 2025, we believe new charging infrastructure will be needed to service this growth. Relative to commoditized consumer charging stations, the market for commercial-scale solutions is more differentiated, with several providers entering the market.

Key companies providing electric vehicle charging solutions in the US include **Tesla**, **ChargePoint**, ABB, Siemens, **Electrify America** (a subsidiary of VW), **EVgo** (acquired by Vision Ridge Partners through a $120.0 million LBO in 2016), **Greenlots** (acquired by Shell in early 2019), **BTCPower** (acquired by Innogy in 2018), Blink, and Efacec. In Europe, companies include Polar/**Chargemaster** (acquired by BP in 2018), **Tesla**, **POD Point**, **InstaVolt**, and **NewMotion** (acquired by Shell in 2017).

This has historically been a competitive market, with large incumbents General Electric and Schneider Electric forced to exit the market due to cost concerns. We believe

19: Ian Gardner, CEO at Royale EV., Panel at Sustain SoCal Driving Mobility Conference, June 25, 2019

partnerships between various players in the ecosystem will be key to streamlining the consumer experience and increasing electric vehicle adoption. In an example of this, two of the largest players in this space, **ChargePoint** and **Electrify America**, announced a partnership to allow cross-charging across networks in June 2019.

Turnkey-managed services: Without the right technology and products, converting a fleet to electric models can be a complicated and expensive process, and this may slow adoption. Scheduling and routing vehicles to charge efficiently can be disruptive to daily operations and harm customer service. Integrated charging solutions (i.e., charging locations, software, and other infrastructure) that can share information with existing fleet management software (i.e., routing, dispatch, and telematics) represents a key point of differentiation, as this enables fleet operators to monitor fleets and power consumption in real time. As charging stations are often located within parking garages or parking lots, the ability to connect with a structure's electric grid can help optimize energy consumption. As this emerging industry develops, we believe fleet managers will increasingly seek full turnkey-managed charging services that effectively outsource the complications of developing and implementing charging infrastructure. Managed service providers including **ChargePoint** and **AMPLY Power** may be well positioned to benefit from fleet electrification.

Autonomy to drive adoption of electric vehicles: The eventual rise of autonomous vehicle fleets could further catalyze the adoption of electric vehicles. Fully electric vehicles have inherent computing advantages that may be more suited to autonomous vehicles relative to combustion engines. In addition to fuel savings and maintenance advantages, the ability to wire the mechanics of a car directly to a computer could help facilitate the deployment of autonomous driving software relative to retrofitting such systems to work with traditional internal combustion powertrains.

Considerations

High capital intensity and thin margins: Developing and manufacturing electric vehicles is a capital-intensive business model with thin margins even at scale. For example, **Tesla** came close to bankruptcy while ramping up production of the Model 3. Electric vehicle maker **Faraday Future** has faced significant financial and management problems, having received a $225 million bridge loan in April 2019 and support from a local government in Inner Mongolia. These companies' difficulties reflect challenges hindering success in the automotive industry, which is stacked with well-funded, entrenched incumbents.

China cutting subsidies: The Chinese electric vehicle industry is in the midst of a shakeout as subsidies have been slashed. This is part of a broader effort by the Chinese government to focus investment dollars toward the best companies and push them to become self-sufficient instead of propping up the unsustainable tail end of the industry. As funding dries up, many unprofitable Chinese electric vehicle startups are likely to face financial pressure. For example, Chinese electric vehicle company **Byton** announced that it would be suspending operations for six months after furloughing hundreds of workers due to difficulties in raising capital.

Branding key to penetrating market: New and lesser-known electric vehicle brands may struggle to gain a foothold in the $440 billion auto market. According to a study by JD Power, leading mass-market car brands generally command a 50%-60% loyalty rate (or percentage of vehicle owners who choose the same brand when trading in or purchasing their next vehicle),[20] creating a barrier to entry for untested and potentially unreliable new car brands. Manufacturers that we believe excel in branding and setting themselves

20: "JD Power 2019 U.S. Automotive Brand Loyalty Study," JD Power, July 16, 2019

apart include **Tesla** and **Rivian**, which are marketing themselves toward environmentally conscious, outdoorsy consumers that are enthusiastic about technology.

Range anxiety hinders consumer adoption: We believe increased consumer adoption will depend on improvements in battery range and charging speeds along with increased deployment of charging infrastructure across the US. As of July 2019, there were approximately 20,000 public charging stations in the US,[21] far less than the approximately 121,988 gas stations in the country.[22] 58% of drivers cited a fear of running out of power, and another 49% cited the low availability of charging stations as a concern, according to a study by Volvo.[23]

Outlook

Investment into electric vehicles remains strong: Despite fears that COVID-19 could delay the electrification of transportation, public and private markets have continued to funnel capital into electric vehicle technology. Mirroring the significant rise in the share prices of electric vehicle companies such as **Tesla**, NIO, and Nikola, startups such as **Rivian** and **QuantumScape** continue to raise outsized financing rounds. **Tesla** continues to set impressive milestones, while traditional automakers, such as Nissan, VW, and Volvo, have not prioritized electrification. We continue to view adoption of electric vehicle technology as a stable secular trend and maintain our favorable long-term outlook on the space.

SPAC funding likely to continue: We expect reverse mergers with SPACs to remain a popular method of raising capital for electric vehicle companies. Thus far, **Canoo**, Chargepoint, **Faraday Future**, **Fisker** Inc, **Hyliion**, **Lordstown Motors**, Nikola Motors, **QuantumScape**, Romeo Power, and **XL Fleet** have all debuted or announced plans to debut on public markets through SPACs. Because they offer quicker time to market and less scrutiny, SPACs are an attractive listing option for electric vehicles companies and, more broadly, startups that are highly capital intensive and in the pre- to early revenue stages. In our view, electric vehicle startups **Lucid Motors**, **Arrival**, and **Karma Automotive** are attractive candidates for a SPAC reverse merger.

Electric vehicles will require automakers to integrate the battery supply chain: Historically, automakers have served as integrators in the supply chain by purchasing parts from different suppliers and vendors. A growing focus on batteries over engines, however, is changing this dynamic as automakers seek to have more control over battery production. We believe automakers that establish strong partnerships with battery suppliers or vertically integrate battery production will be better positioned to reduce costs and thrive. **Tesla** has closely partnered with Panasonic to cut battery costs, improve affordability, and increase profits. Additional examples include **Volkswagen**'s contract with Korea's SKI and its $540.0 million joint venture with **Northvolt**, GM's $2.3 billion joint venture with LG Chem, and BYD with its internally produced batteries.

Legacy automakers with fully separate electric vehicle platforms more likely to succeed: Automakers that have dedicated electric vehicle platforms are in a more favorable position than those that have adapted internal combustion platforms for batteries. For example, **Volkswagen** has invested $7.0 billion into its MEB electric vehicle platform,

21: "There Are More Than 68,800 Electric Vehicle Charging Units in the United States," United States Department of Energy, United States Office of Energy Efficiency & Renewable Energy, July 8, 2019
22: 2020 NACS/Nielsen Convenience Industry Store Count, February 2020
23: "The State of Electric Vehicles in America," Volvo, February 26, 2019

which will support multiple sizes of vehicles and is expected to sell 15 million units over the next 10 years.[24] Conversely, manufacturers including **BMW**, Jaguar, and Land Rover have adopted an incremental, hybridized approach that utilizes existing combustion engine platforms. While automakers can save money using the latter approach, we believe it weakens long-term competitive positioning as a new wave of electric vehicle startups disrupts the industry.

Government initiatives will fast-track electrification of passenger vehicles: Many countries are taking actions to reduce traffic congestion and carbon output. The UK, Germany, and France have announced plans to ramp up subsidies for electric vehicles. China's Ministry of Industry and Information Technology has set a target for electric vehicle sales to represent 25% of new vehicle sales by 2025, up from approximately 5% today.

As a result, total electric vehicle registrations in Europe rose 127% YoY in July.[25] While total new vehicle sales are projected to decline by 20% in 2020, we expect sales of electric vehicles to decline by just 6%. Our market forecast assumes electric vehicles achieve cost parity with gas-powered vehicles in 2025.

The upcoming US election could have a significant impact on the growth of this industry. US presidential candidate Joe Biden has made electrification a focal point of his plan to combat climate change, including a plan to invest $2 trillion into electrification and renewables, which includes the installation of 500,000 public charging stations in the next four years. Democratic victories in the White House and Senate could lead to substantial investment in electric vehicle charging networks and increased subsidies for electric vehicles.

Urban air mobility to be enabled by electrification: Electric air taxis could dramatically lower the cost of long-distance urban transportation while reducing emissions and traffic congestion within cities. Although the industry faces formidable technological and regulatory hurdles, we believe nontraditional corporate investors with vested interests in shaping the evolution of the transportation industry will continue to fund R&D in the space in the long term. Two key startups in the space, **Joby Aviation** and Lilum, have raised large mega-rounds in early 2020 and should be well positioned to sustain themselves in the near to medium term. Additional players in the air taxi space include **Volocopter**, **EHang**, **Skyryse**, and **Karem Aircraft**. We are seeing evidence of the first logistical applications of urban air mobility being fast-tracked due to the COVID-19 crisis. China-based drone maker Ehang announced that it transported essential medical supplies and workers to hospitals using unmanned aerial vehicles in late February. In the US, UPS and CVS have reportedly partnered to deliver medical supplies to retirement communities in Florida via drone. Meanwhile, North Carolina has given the green light for medical and food drone deliveries from various startups including **Flytrex**, Matternat, and **Zipline**.

Freight headwinds will be solved: Electrified freight transportation faces several challenges; for one, the weight of batteries reduces available cargo space. In addition, trucks may need a considerable amount of charges to travel long distances, which degrades battery longevity over time. However, we believe these headwinds are solvable in the medium term, especially as the industry has made progress surrounding these complications in recent years. For example, in 2016 it was estimated that driving a semitruck 500 miles would require lithium ion batteries weighing 46,000 pounds (half

24: "Electric Vehicle Architecture Divides Automakers," Automotive News, Nick Gibbs, September 21, 2019
25: "Tesla Blown Away as Renault Dominates Europe's July Electric Vehicle Sales Party," Forbes, Michael Taylor, August 27, 2020

the weight of the truck itself).[26] Today, **Tesla**'s semitruck is reported to exceed a 500-mile range with a drivetrain that weighs an estimated 12,500 pounds, just 1,000 pounds over an equivalent diesel sleeper. Additionally, we expect fast charging issues will be less problematic as the electric charging ecosystem improves and as modular systems that enable battery swapping become more feasible. Finally, as 80% of domestic freight tonnage is under 550 miles,[27] most charging will likely be done on fleet lots, which shouldn't result in much battery degradation.

26: "Freight Transportation Modal Shares: Scenarios for a Low-Carbon Future," US Department of Energy, Office of Energy Efficiency and Renewable Energy, March 2013
27: Ibid.

Supplemental materials

Select company analysis

Business overview

AEye's MOEMS-based lidar system is software definable, enabling perception engineers to configure scanning for each use case. The system allows users to define and utilize multiple scan patterns within a frame and zone in on high-resolution regions of interest. Bore-sighting cameras with agile lidar enable 2D computer vision algorithms to extract true color and additional perceptual data from 3D point clouds.

In our view, the most successful lidar companies will be those that provide expertise in both software and hardware. **AEye**'s dual software and hardware focus enables it to interpret data at a much faster speed than typical solutions, enabling prompt information processing and decision making.

Additionally, **AEye**'s business model benefits from the unique software definition of its product. Being able to focus on the most relevant information in real-time enables fewer sensors per vehicle, reducing the total cost for potential buyers. Also, the same system can be used for multiple use cases, allowing automakers to source the same system for multiple vehicle form-factors. Finally, outsourcing manufacturing enables **AEye** to maintain a leaner business model relative to competitors.

Leadership

Co-founder & CEO: Luis Dussan

President: Blair LaCorte

Co-founder & CFO: Ransom Wuller

Co-founder & head of strategy: Jordan Greene

Competitors

Velodyne, **Quanergy**, **Surestar**, **LeddarTech**, **Innoviz Technologies**, Oryx, **Aeva**, **Robosense**, **Trilumina**, **Luminar**, **Innovusion** and **Ouster**

Financing history

Raised-to-date: $72M over six deals

Most recent round: Late-stage VC round (March 2020)

$10M of venture funding in the form of convertible debt from undisclosed investors

Last valued at $220M (January 2019)

First institutional round: $21M (January 2016)

Ownership

Taiwania Capital, Kleiner Perkins, Aisin/Pegasus Tech Ventures, Hella Ventures, Subaru-SBI, **Airbus** Ventures, LG Electronics, Intel Capital, and an undisclosed OEM

Select company analysis

ZOBA

Business overview

Zoba is a data analytics platform that uses spatial analytics and machine learning to predict consumer demand for scooters, bikes and cars. The company charges a subscription fee to shared mobility providers to optimize vehicle placement, which improves utilization and reduces operational costs. **Zoba**'s platform is currently utilized by major industry leaders in the micromobility and Auto commerce industries. As shared mobility applications face increased investor pressure to become profitable, data analytics could be a key component of reducing costs. Additionally, the industry-wide switch to swappable batteries could be a major catalyst for usage analytics, as swappable batteries reduce the need for vehicle pickups and open the door for alternative ways to redistribute vehicles.

We believe data analytics tools such as **Zoba** are well positioned as acquisition targets for shared mobility operators. As shared mobility applications face increased investor pressure to rationalize costs, data analytics could be a key component of improving fleet utilization and reducing costs. Additionally, the industry-wide switch to swappable batteries could be a major catalyst for usage analytics, as swappable batteries reduce the need for vehicle pickups and open the door for alternative ways to redistribute vehicles.

Leadership

Co-founder & CEO: Daniel Brennan

Co-founder: Joseph Brennan

CTO: James Dreben

Competitors

Superpedestrian, Joyride, **Zagster** and Fleetbird

Financing history

Raised-to-date: $3.6M to date over four deals

Most recent round: Seed round (February 2019) $3 million of Seed 1 funding in a deal led by CRV

Last valued at $12.5M

Ownership

CRV, Anthony Goldbloom, Founder Collective, Matthew Brezina, Harvard Innovation Launch Lab, MassChallenge, Mark Cuban, The Graduate Syndicate

Select company analysis

WaveSense

Business overview

Provider of ground penetrating radar-based remote sensing and systems designed to offer accurate mapping and localization. The company's radar system sends an electromagnetic pulse into the ground and uses reflections of underground features to generate a base map. Autonomous vehicles currently struggle with perceiving their surroundings in inclement conditions, and **WaveSense**'s tech helps alleviate that issue. In the future, autonomous vehicles will need a suite of sensors to handle various weather and road conditions, and **WaveSense**'s offering helps fill in the gap of underground sensing.

Leadership

Co-founder & CEO: Christopher Bolat

Co-founder & CTO: Byron Stanley

Competitors

Vayyar Imaging, **Echodyne**, **Arbe** Robotics, **Oculii**, **Metawave**, **Zendar** and others

Financing history

Raised-to-date: $3.0M over one financing

Most recent round: $3.0M seed round (August 2018)

$12.0M post-money valuation

Ownership

NOMO Ventures, Rhapsody Venture Partners, VAS Ventures, Plug and Play Tech Center, Greentown Labs

Select company analysis

ENEVATE

Business overview

Enevate develops and licenses advanced silicon-dominant Li-ion battery technology to automotive OEM and electric vehicle battery makers. The company's technology enables five-minute extreme fast charging with high energy density, low temperature operation for cold climates, low cost and safety advantages over conventional Li-ion batteries. **Enevate**, which counts John Goodenough, a Nobel laureate for his work on lithium ion batteries, as an advisory board member, has a 250+ patent portfolio and has secured partnerships with key OEMs and Tier-1 suppliers.

We believe **Enevate** is well-positioned to benefit from increased sales of electric vehicles over the long term. The company's focus on fast-charging differentiates it from next-generation battery competitors. Additionally, we believe **Enevate**'s licensing-based business model is more defensible during a downturn relative to materials supplier competitors.

Leadership

CEO: Robert Rango

Founder & CTO: Benjamin Park, Ph.D

CFO: Sameer Rao

Competitors

Sila Nanotechnologies, **StoreDot**, **Nexeon**, **QuantumScape**

Financing history

Raised-to-date: $106.2M over 12 financings

Most recent round: Corporate round from Bangchak Petroleum in April 2019

First institutional round: $3.2M (April 2008)

Ownership

Mission Ventures, LG Chem, Alliance Ventures, Presidio Ventures, Lenovo, Essex Capital, Infiite Potential Group, ATEL Capital Group, CEC Electronics, Tsing Capital, Quantum Valley Investments, Draper Fisher Jurvetson Management

Select company analysis

simpler studios

Business overview

Simpler Studios has developed a driver-assistance application that provides drivers and cyclists with curated hazard notifications. The startup has compiled a nationwide database of crash hotspots by using machine learning and predictive analytics on tens of millions of police reports. Hazard notifications can be curated based on type of driver. For example, truckers can be notified of low bridges, while cyclists can be notified of intersections commonly involving bicycle-car collisions. They can also be alerted to different types of conditions, such as the time of day when deer are more likely to cross country roads or adverse weather causing dangerously slippery conditions on otherwise benign corners.

We believe **Simpler Studios'** platform has many potential use-cases. Large technology companies such as **Alphabet** or **Apple** could improve their maps products by providing drivers and cyclists with advanced warning of hazards ahead. Alternatively, insurers or fleet managers could utilize Simpler's data to improve routing and decrease accident risk. Finally, automakers could differentiate their vehicles by offering curated hazard notifications as a premium safety feature.

Leadership

Co-founder: Daniel Witriol

Co-founder: Dennis Cheng

Competitors

Tnedicca

Financing history

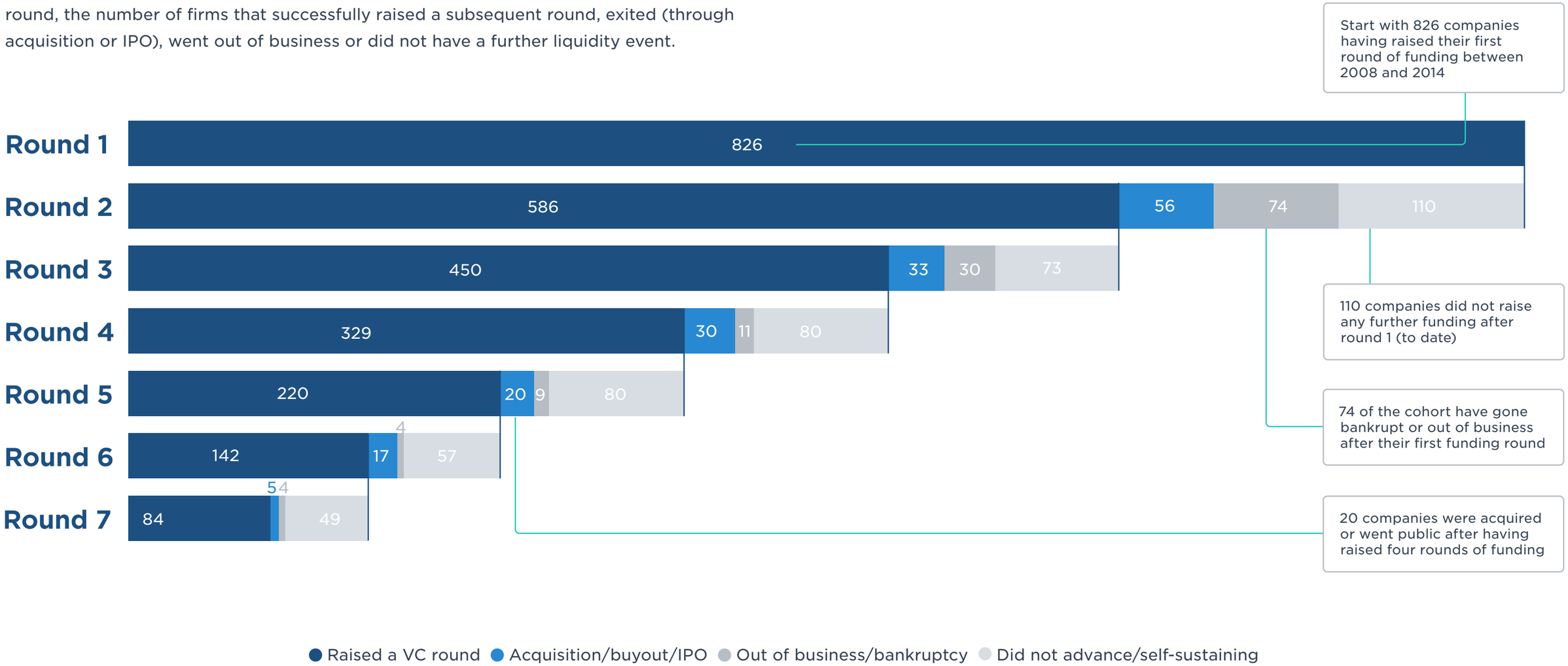
N/A

Ownership

N/A

Mobility tech VC funnel

This VC funnel uses PitchBook data to analyze the VC funding life cycle by highlighting, by round, the number of firms that successfully raised a subsequent round, exited (through acquisition or IPO), went out of business or did not have a further liquidity event.

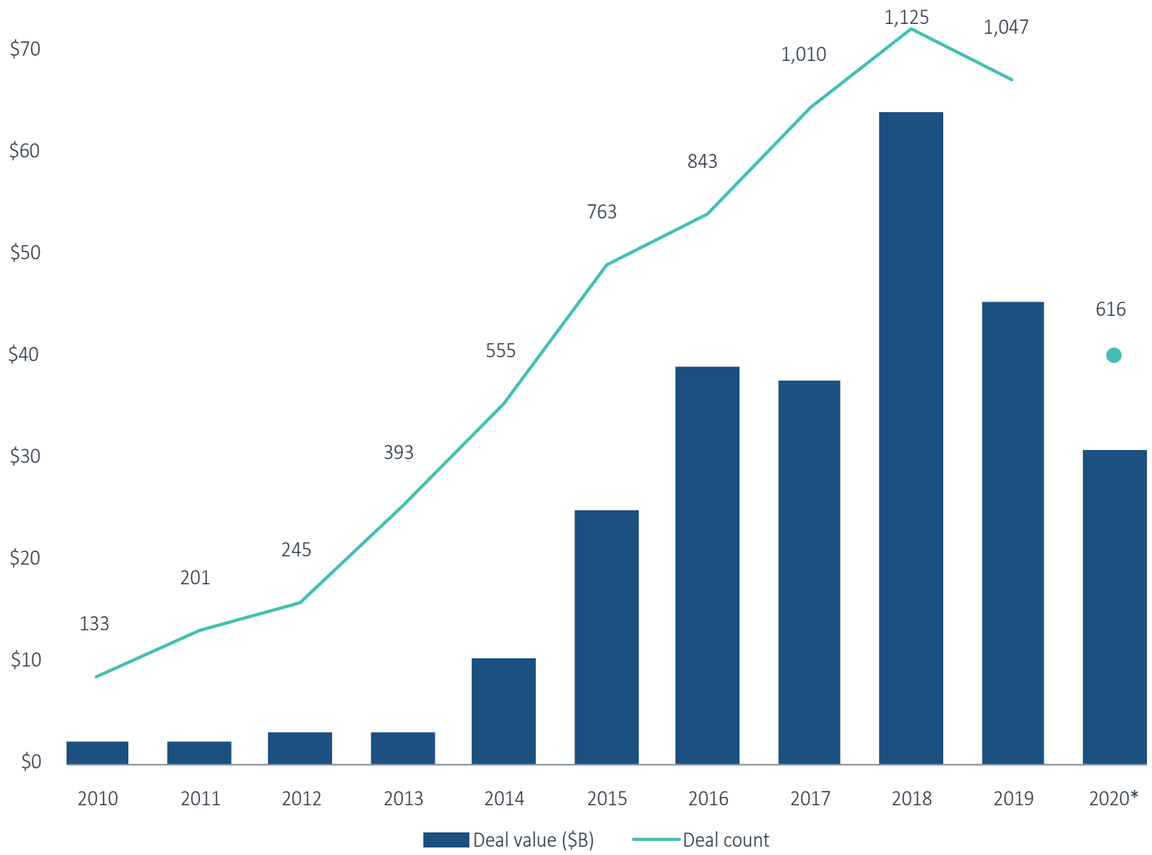


SUPPLEMENTAL MATERIALS

Additional VC data

Figure 68.

Mobility tech VC deal activity



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 69.

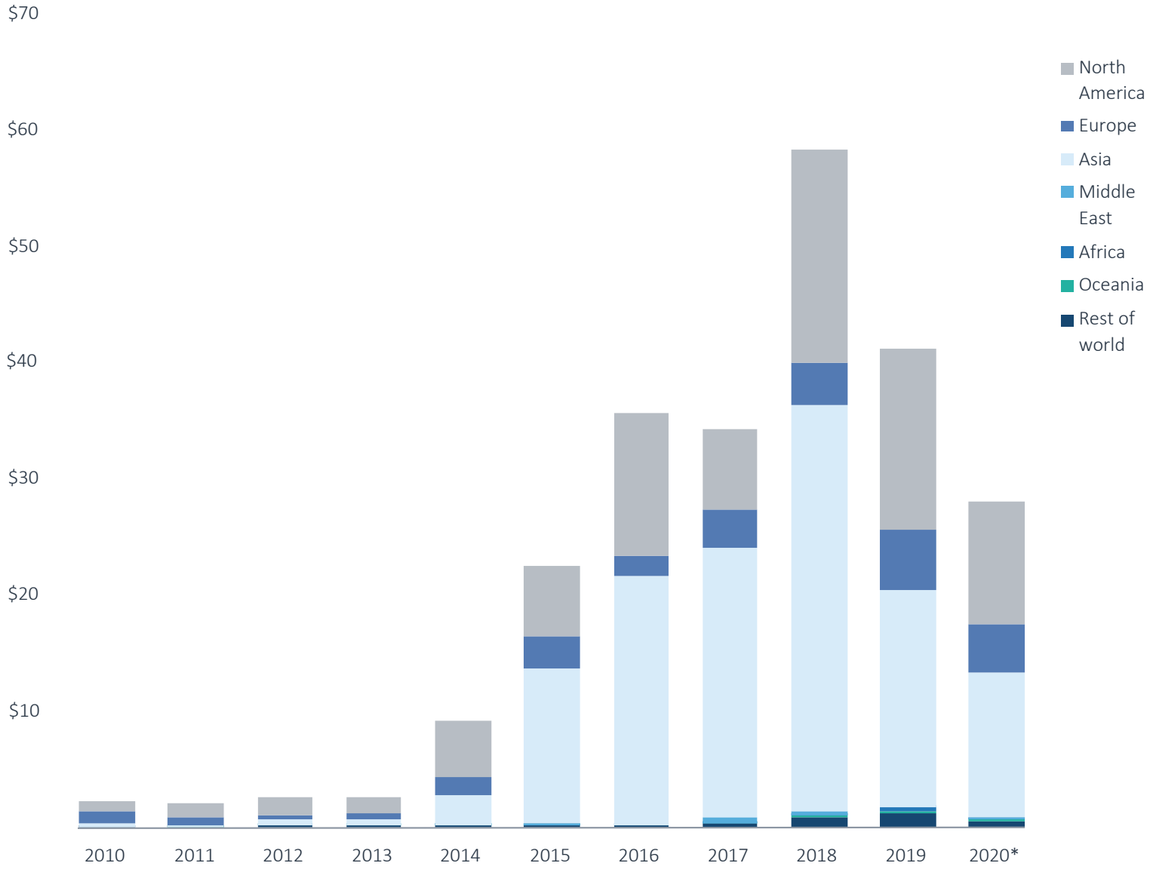
Top 10 mobility tech VC deals in Q3 2020 by size

COMPANY	CLOSE DATE	DEAL SIZE ($M)	POST-MONEY VALUATION ($M)
Weltmeister	September 9, 2020	$1,470.0	N/A
Northvolt	September 29, 2020	$600.0	N/A
Xpeng	July 20, 2020	$500.0	N/A
Miss Fresh	July 23, 2020	$495.0	$3,500.0
Kavak	September 1, 2020	$397.2	$1,150.0
ChargePoint	August 5, 2020	$367.3	$1,367.3
Xpeng	August 3, 2020	$300.0	N/A
Rappi	September 24, 2020	$300.0	$3,500.0
AUTO1 Group	July 30, 2020	$291.3	N/A
Kymeta	August 25, 2020	$215.0	$375.0

Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 70.

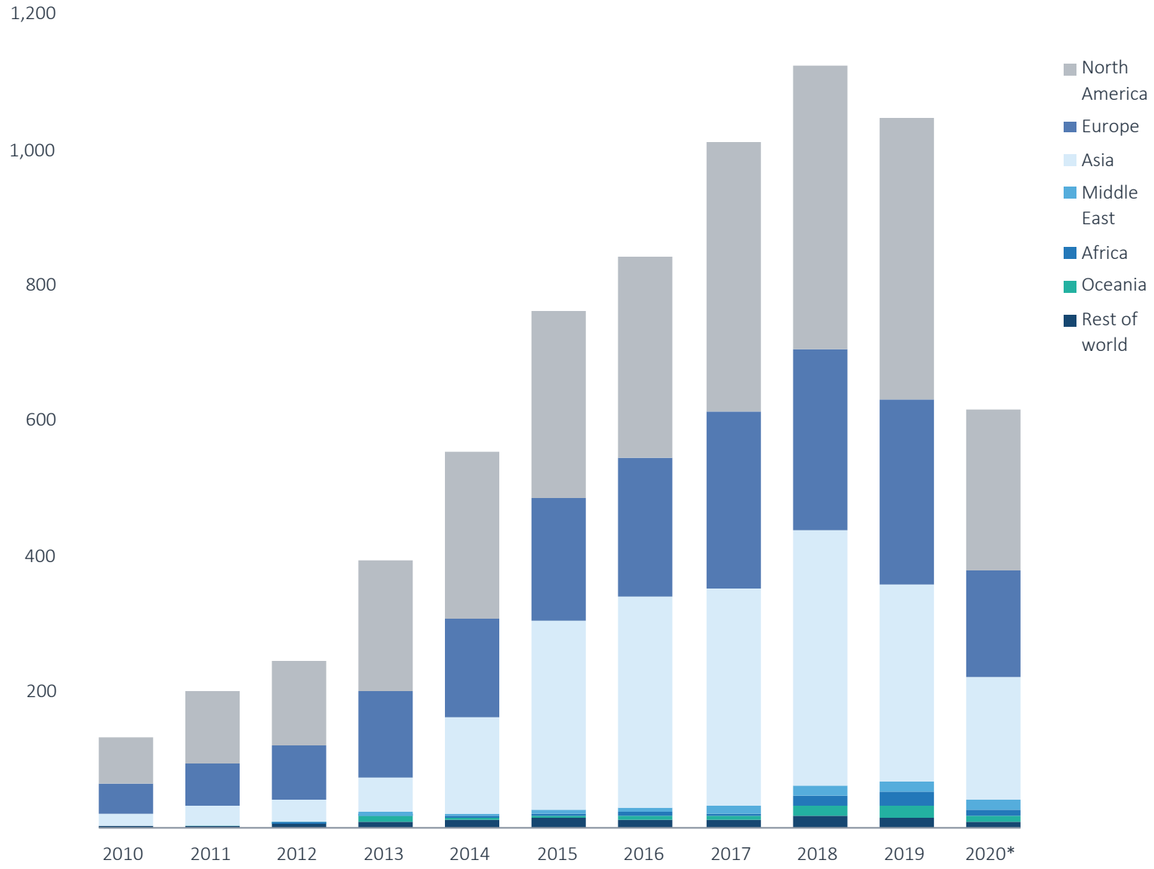
Mobility tech VC deals ($B) by region



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 71.

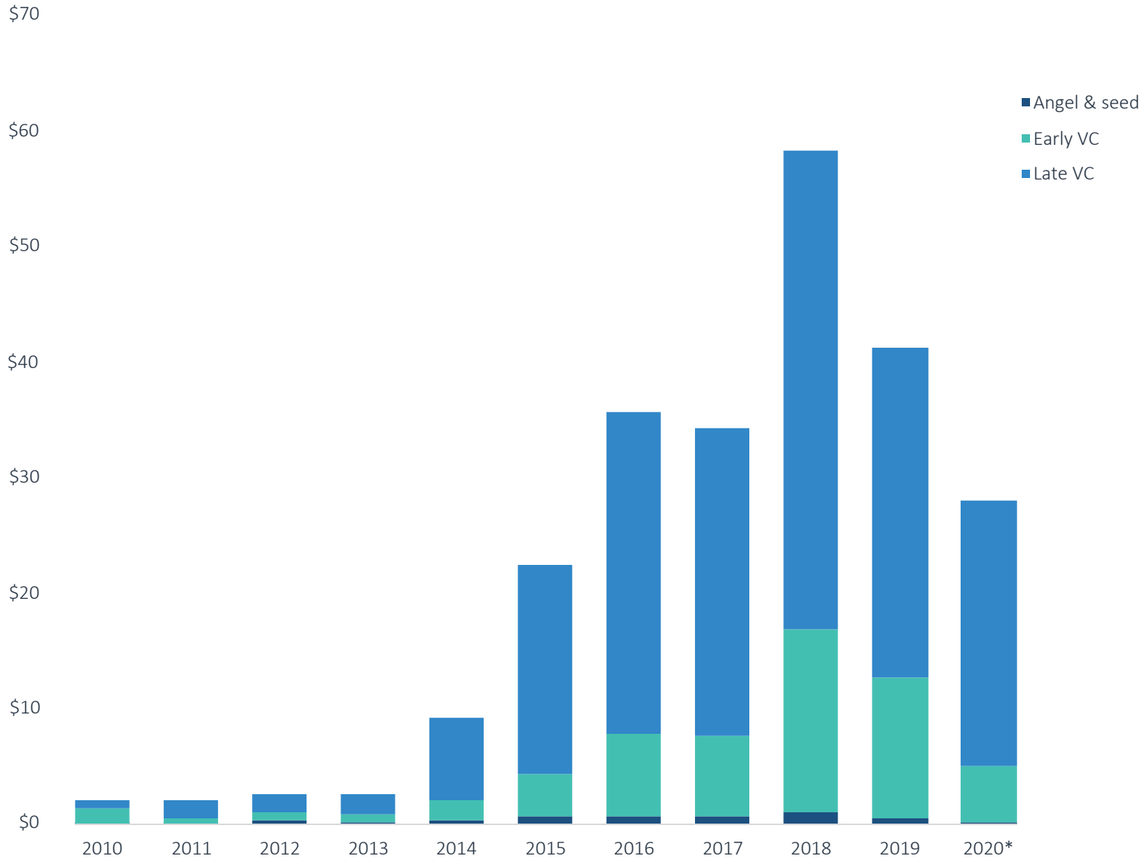
Mobility tech VC deals (#) by region



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 72.

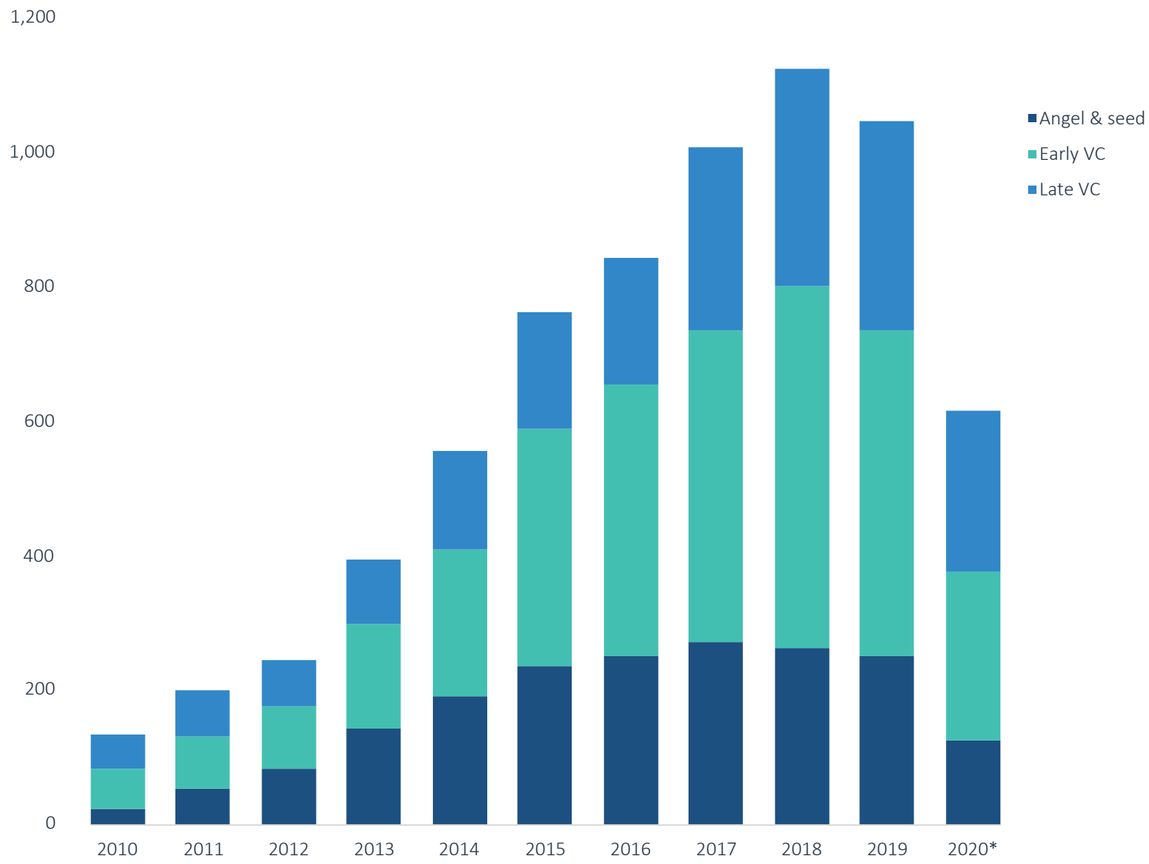
Mobility tech VC deals ($B) by stage



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 73.

Mobility tech VC deals (#) by stage



Source: PitchBook | Geography: Global | *As of September 30, 2020

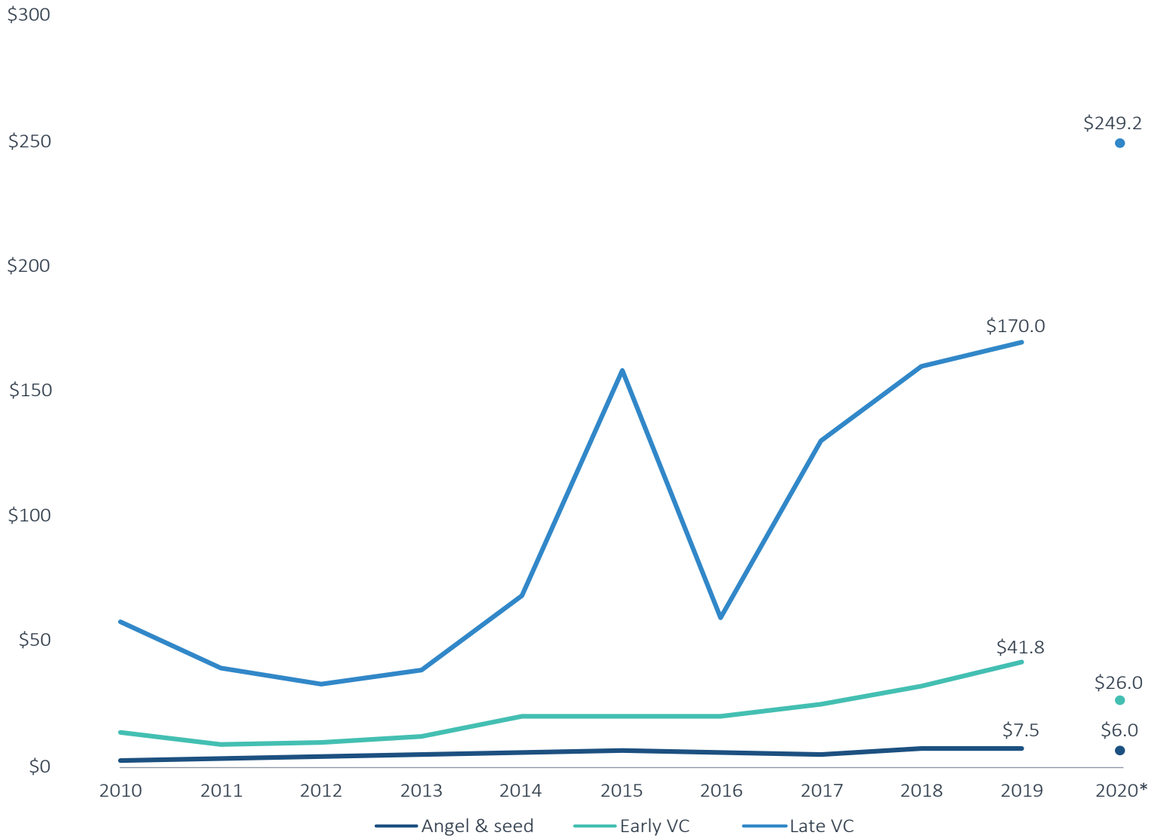
Figure 74.

Median mobility tech VC deal size ($M) by stage

Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 75.

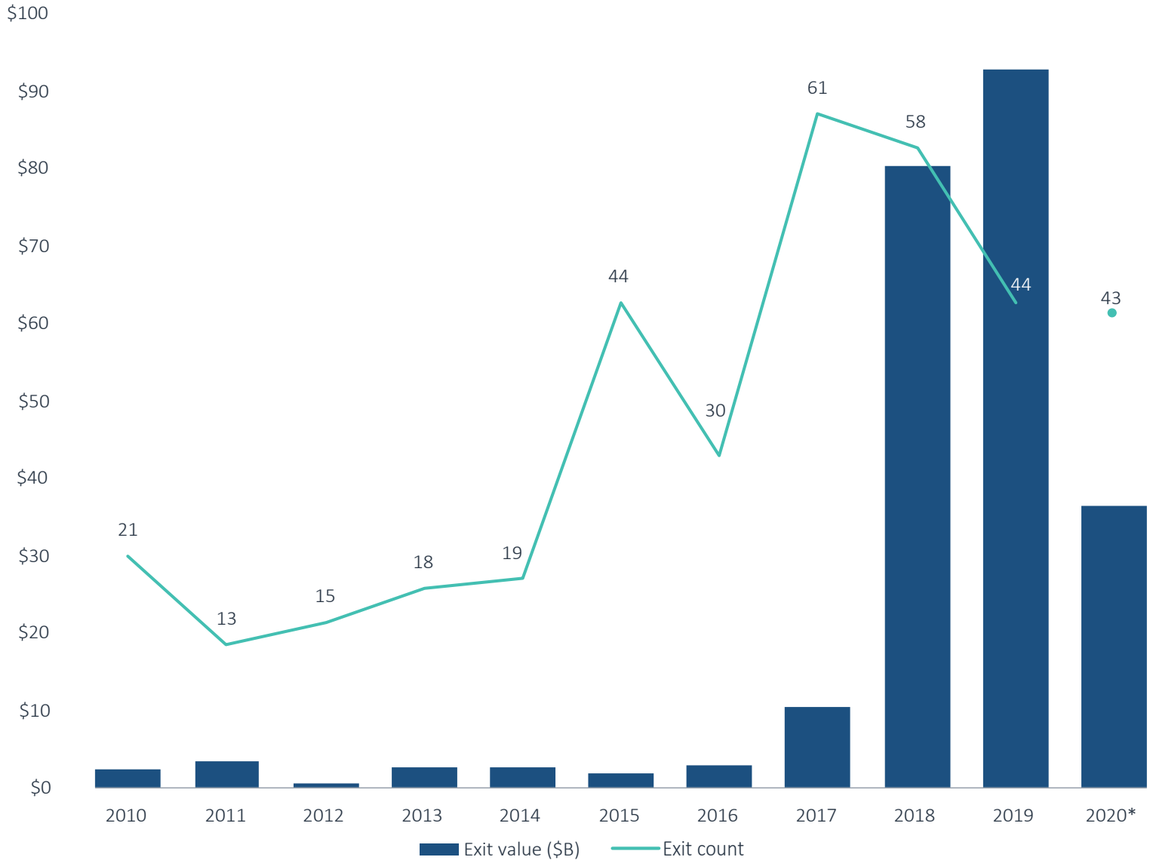
Median mobility tech VC pre-money valuation ($M) by stage



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 76.

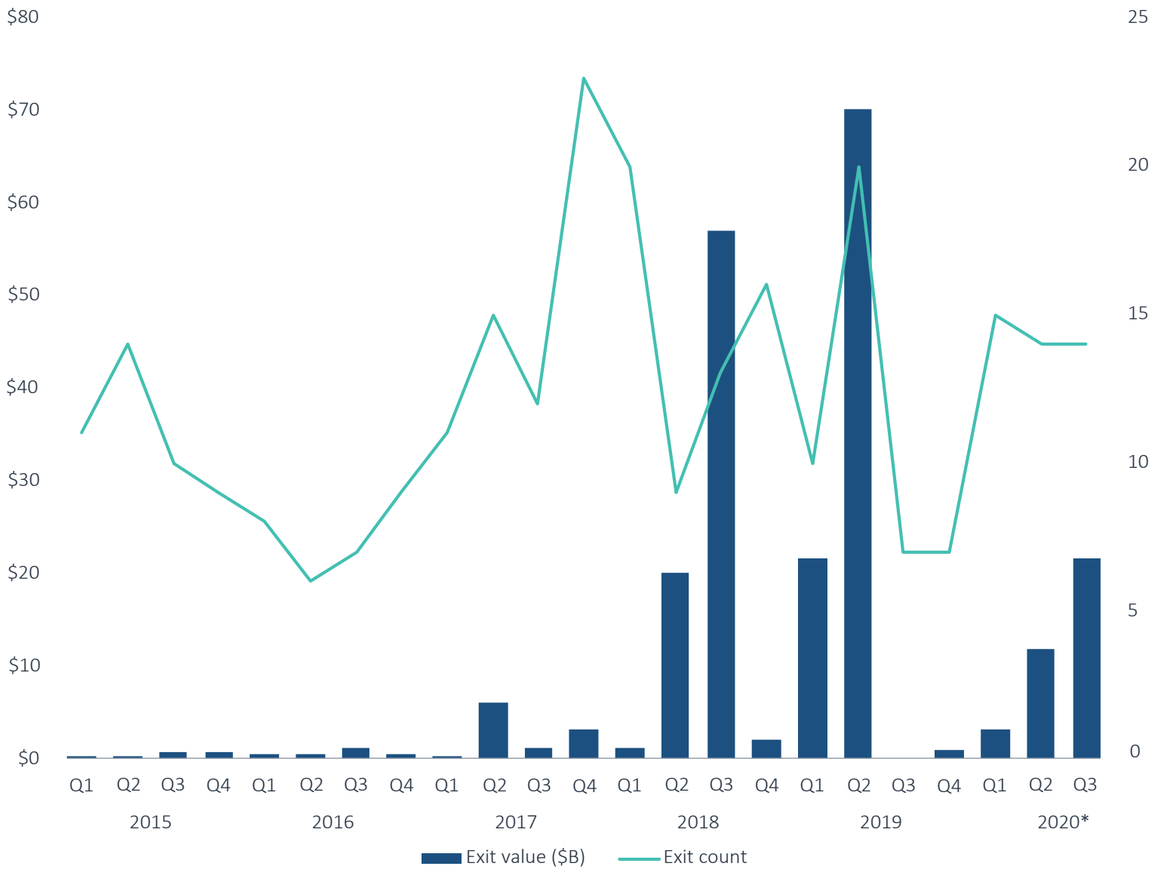
Mobility tech VC exit activity



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 77.

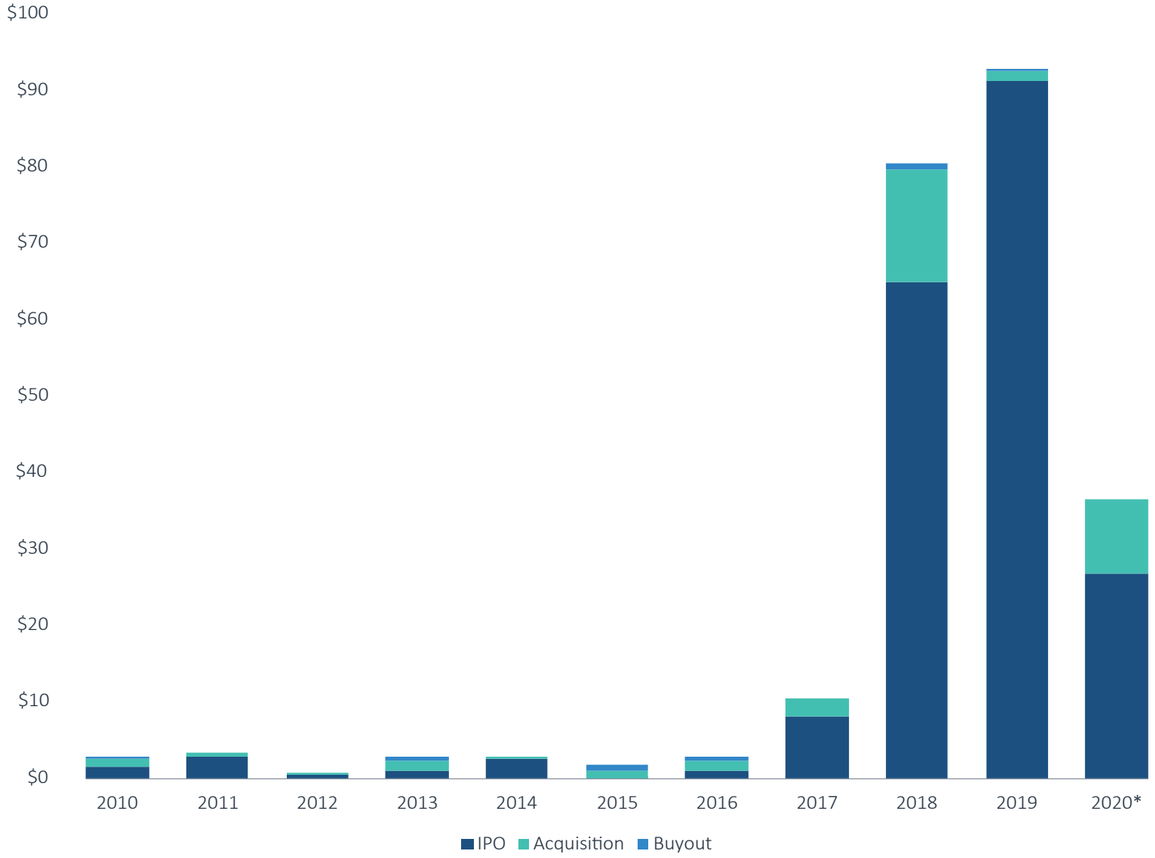
Mobility tech VC exit activity



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 78.

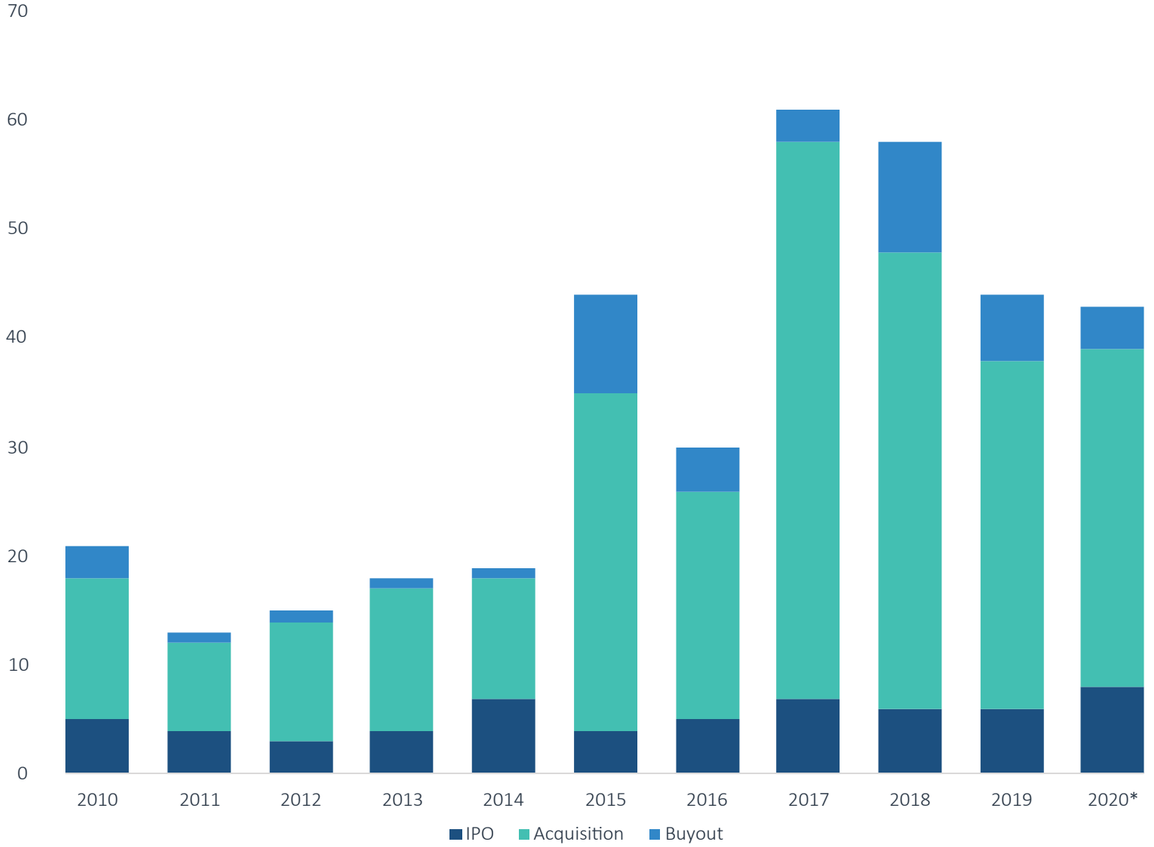
Mobility tech VC exits ($B) by type



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 79.

Mobility tech VC exits (#) by type



Source: PitchBook | Geography: Global | *As of September 30, 2020

Figure 80.

Top VC investors in mobility tech since 2018

INVESTOR	DEAL COUNT*
Alumni Ventures Group	35
Sequoia Capital	28
Accel	28
Sequoia Capital China	27
500 Startups	25
FJ Labs	24
GGV Capital	23
Toyota AI Ventures	20
Trucks Venture Capital	20
Maniv Mobility	19
NGP Capital	18

INVESTOR	DEAL COUNT*
Sequoia Capital India	18
BMW i Ventures	17
G Squared	17
Andreessen Horowitz	17
GV	17
Qualcomm Ventures	17
IDG Capital	17
Baidu Ventures	17
TransLink Capital	16
SOSV	16
MicroVentures	16

INVESTOR	DEAL COUNT*
Lightspeed Venture Partners	15
Fontinalis Partners	15
8VC	15
Index Ventures	15
Autotech Ventures	14
Fraser McCombs Capital	14
General Catalyst	14
DST Global	14
Intel Capital	14
Prologis Ventures	13
Next47	13

INVESTOR	DEAL COUNT*
Bain Capital Ventures	13
Robert Bosch Venture Capital	13
Eastern Bell Venture Capital	13
Legend Capital	13
Bessemer Venture Partners	13
Khosla Ventures	13

Source: PitchBook | *As of September 30, 2020

Buyers list

Figure 81.

Strategic buyers (corporations, holding companies & private companies)

Strategic buyers in the mobility vertical tend to be automakers, suppliers, technology companies and chipmakers. These companies often take a dual approach of developing mobility technology in-house while partnering with or acquiring key startups in the space. Over the near to medium term, we anticipate the landscape of strategic buyers to increasingly tilt toward large technology companies.

NAME
Alphabet
Amazon
Apple
Ford
Intel
Nvidia
Toyota
Uber

Source: PitchBook

Figure 82.

Top PE investors since 2008 (PE groups)

PE-backed technologists in this space tend to provide connected car and electric vehicle technologies. Revenue growth, operating profit and EBITDA growth, margin improvement and capital efficiency are KPIs for investors in this space.

NAME	SECTOR INVESTMENTS*
The Carlyle Group	53
Ridgemont Equity Partners	36
Penfund	33
Caisse de dépôt et placement du Québec	31
Kinderhook Industries	31
Ardian	31
Leonard Green & Partners	29
H.I.G. Capital	28

Source: PitchBook | *As of September 30, 2020

About PitchBook Emerging Tech Research

Independent, objective and timely market intel

As the private markets continue to grow in complexity and competition, it's essential for investors to understand the industries, sectors and companies driving the asset class.

Our Emerging Tech Research provides detailed analysis of nascent tech sectors so you can better navigate the changing markets you operate in—and pursue new opportunities with confidence.

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