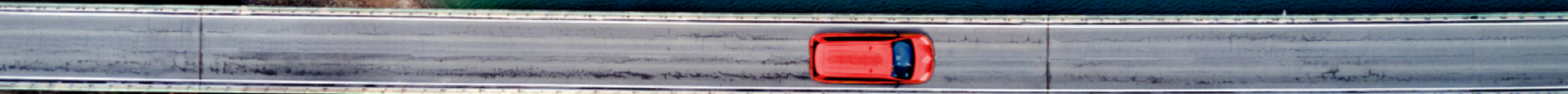


AUTOMOTIVE
DISRUPTION
RADAR
#5

Mobility's great leap forward

A world on the verge of autonomy



March 2019

A world on the verge of autonomy

The top specs: Report summary

The developed world is within sight of becoming an autonomous mobility society thanks to a great leap forward in the sector in the past two years. Indicators from the fifth edition of the Automotive Disruption Radar, a twice-yearly report and survey now covering 17 domestic markets, show significant and rapid progress towards sustainable mobility, with large-scale services perhaps just five years away.

While acknowledging that the transition to autonomous mobility will not happen overnight, ADR 5 finds that all countries and stakeholders are making giant strides. China again topped the list, but from the US to Japan, regulatory hurdles are coming down, critical infrastructure and investment are going up, and customer interest in the technology is holding firm.

There were several big developments in the six months following ADR 4. For example, the US and South Korea launched the world's first commercial 5G services, a vital component of autonomous driving. Other markets, including China, Singapore, and Dubai (UAE) allocated frequencies. And, in the

customer interest category, it's clear that car buyers have seen through the hype surrounding autonomous driving. ADR 5, which included a survey of 16,000 people across the 17 markets, shows that the number of people who would use such technology has remained at about 50% since the first ADR two years ago.

Meanwhile, the trend towards electric vehicles (EV) is growing. For example, the EV sales share in China, the world's largest market, has more than tripled in the past two years to 4.3% of total vehicle sales. Customers now cite a lack of public charging infrastructure as their main reason for not buying an EV, underlining a clear need to satisfy further demand.

ADR 5 also shows that in the past two years more and more cities have clamped down on gasoline or diesel powered vehicles. Of the 221 cities analyzed, the number with at least a minor restriction grew from 24% to 44%, showing a clear push towards EVs.

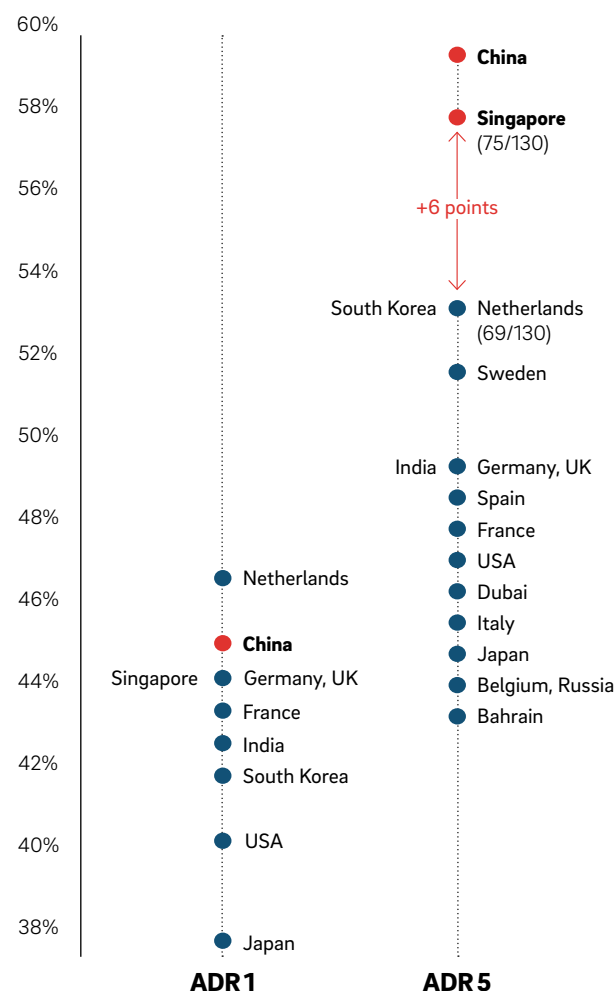
Investors, whether traditional automakers, mobility actors or out-of-sector players, have also given the industry a boost recently. For example, the Japanese conglomerate Softbank is sinking up to USD 1 billion in Nuro, a US startup specializing in autonomous vehicles (AVs) that transport shopping over the "last mile" to customers' homes or offices. Two other AV startups, Aurora and Zoox, have both secured up to USD 500 million in funding.

Interestingly, investment trends have changed in the past two years, with venture capitalists now

Country scoring in ADR first and last edition

China and Singapore have a clear lead in disruption

ADR scoring (% of maximum score)



Source: Roland Berger

focusing on artificial intelligence. Perhaps they view the hunt for more “intelligent” algorithms that use even less computing power as the last main technical hurdle to fully autonomous driving.

Such investments point to a second key finding in ADR5: It is the tech giants and agile and innovative startups, such as the Google offshoot Waymo, that are making all the headway in the AV industry, less the traditional automotive industry giants. They are outpacing and out-thinking their established rivals, who are still catching up with developments in areas such as battery technology. This failure to keep up threatens their margins in the mid term, meaning they urgently need new ideas.

Speed will be of the essence, with ADR5 highlighting the steep growth trajectory of the AV industry. It’s worth noting that in a report just three years ago,¹ we predicted that fully autonomous robocabs “could seize control of more than one third of the worldwide automotive mobility market by 2030.” This may have sounded like wishful thinking at the time. But, despite all the technical hurdles still facing the industry, it now seems like commercial services with significant revenues could be a reality in just five years’ time.

¹ A CEO agenda for the (r)evolution of the automotive ecosystem, Roland Berger, March 2016

Analysis: How to navigate the new mobility world

The ADR5 survey offers plenty of indications that large-scale sustainable mobility is just around the corner. But it can’t answer two important questions: what will this new world look like and what are its implications for industry players? Here we offer a short analysis of both. A snapshot of this new world may look something like this:

- Manufacturers will take a purpose-built approach to vehicles, with demand driving body design and interior concepts
- Smart delivery systems with autonomous last-mile vehicles will become the norm
- The widespread use of traffic flow algorithms will mean there will be fewer traffic jams and more available parking spaces
- Electricity will be abundant, cheap and clean thanks to smart grid solutions that include a high share of renewables
- There will be an enhanced awareness of sustainable resource use and recycling

The implications of this new mobility landscape are varied. The purpose-built approach is particularly important as it will offer significant benefits across key mobility indicators. Roland Berger’s analysis indicates that resource consumption in vehicle production could fall by 65% as a result of it, driven by the higher re-use rates of purpose-built vehicles. In addition, higher utilization rates of robocabs offer the promise of up to 50% lower mobility costs for customers.

The climate will benefit too, with CO₂ emissions in the mobility sector falling by as much as 60%. And urban areas will become cleaner as more efficient parcel services, including drone-based services, lead to an estimated 14% fall in traffic jams. Finally, increased driver automation will result in a 50% increase in road safety levels.

But the new world will also pose challenges for the established industry. For example, many OEMs have announced multi-billion euro investments in e-mobility, and it is unlikely that they can afford to invest further in AI, 5G or other key autonomous driving technologies.

As a result, we expect two key changes to the market in the long term. First, demand will shift towards purpose-built vehicles due to their cheaper running costs, lower emissions, increased convenience and improved safety compared to current, personal-use vehicles. Second, new vehicle concepts will turn the traditional idea of the car on its head, as happened when the car replaced motorized carriages more than a century ago.

Traditional OEMs and suppliers will have to adapt to this new sustainable mobility environment. This will mean defining their specific business model in a market focused on purpose-built vehicles. It will also require them to identify and hone in on their target market, and figure out how best to serve it. Partnerships, including with potential investors, may be key to this.

Under the hood: Detailed report findings

ADR5 builds on the four previous ADR editions, which covered 11, 13 and then 14 countries. ADR2 found that Asian countries were taking a lead in autonomous driving while the Dieselgate scandal distracted mature markets. ADR3 noted a rapid shift towards new mobility services since ADR1 in March 2017. ADR4 found that China had established a clear lead in disruptive mobility services.

The latest edition, now including 17 markets and a survey of 16,000 people, was scored according to 26 industry indicators covering five dimensions. Below is a summary of the main findings, by dimension. Overall rankings are shown on page 10.

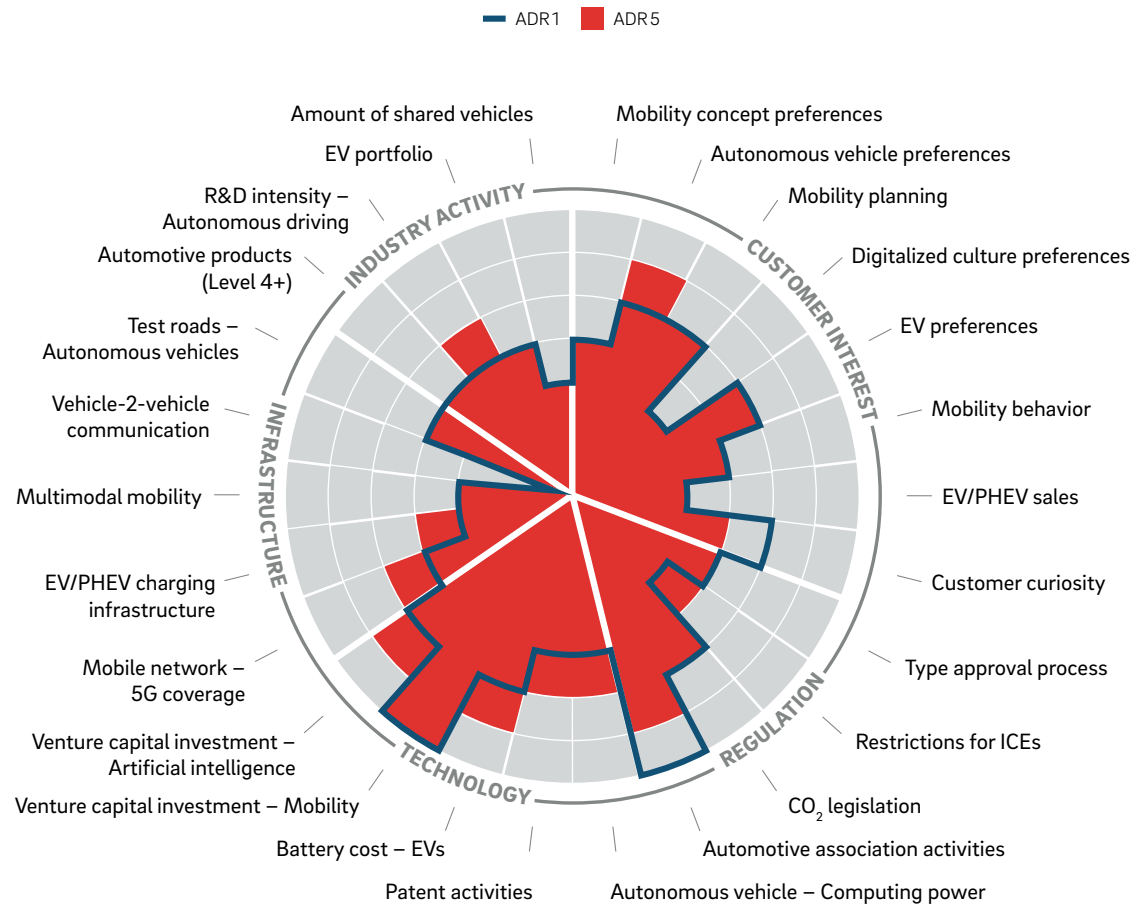
CUSTOMER INTEREST

Many people thought the buzz surrounding autonomous driving would die away as much-hyped robocabs and other services failed to materialize in recent years. But ADR5 shows that customers are keeping faith with the technology and not losing interest. A total of 45% of survey respondents said they would give up their cars in favor of robocab services, rising to 50% among city dwellers. This is roughly the same as in previous ADRs.

The desire to drive is also falling. While half of ADR5 survey respondents said they are not yet ready to use AVs, of these, only 20% said it was because they wanted to drive their vehicle – half as

AUTOMOTIVE DISRUPTION RADAR – ISSUE #5

GLOBAL SCORE PER INDICATOR (from 0 to 5)



Source: Roland Berger

many as two years ago. Instead, most now say a lack of trust in the technology is their main reason for not using an AV, suggesting that if safety concerns can be overcome, then other problems will be readily surmountable.

Another positive was the huge jump in EV sales, rising from 1.6% of total car sales in 2017 to 2.6% in 2018. Sweden and the Netherlands led the way, with EV sales increasing from 4.7% to more than 7% and 2% to 5.3%, respectively. A planned tax break for company EVs was a key driver of the growth in the Netherlands.

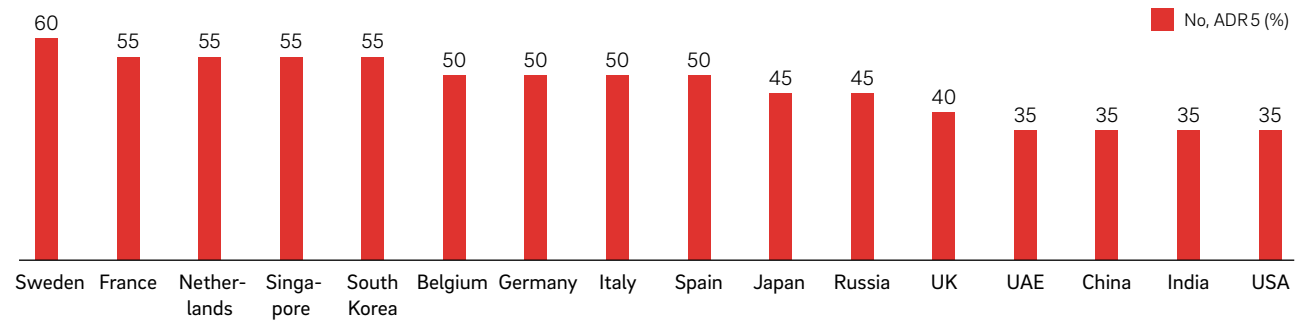
Interestingly, the EV sales figures contrast sharply with levels of interest in the vehicles themselves. Overall, there was only a fractional fall in the number of people considering buying one (35%), but this covered up major slides in some of the big markets like Germany (35% to 25%), Japan (25% to 15%), the USA (20% to 10%) and even EV-friendly Sweden (45% to 30%).

This may have something to do with perceptions about EV networks. For example, in China, the world's biggest EV market with 1.1 million of the cars sold last year, high prices and a lack of charging infrastructure are the main reasons given for not buying an EV. This is despite falling prices and the fact that the public charging network has grown by 40% in the past year.

Share of potential robocab¹ users

Sweden exhibits the highest rate of EV/PHEV sales – Global progression of share and absolute values except in Japan and Russia

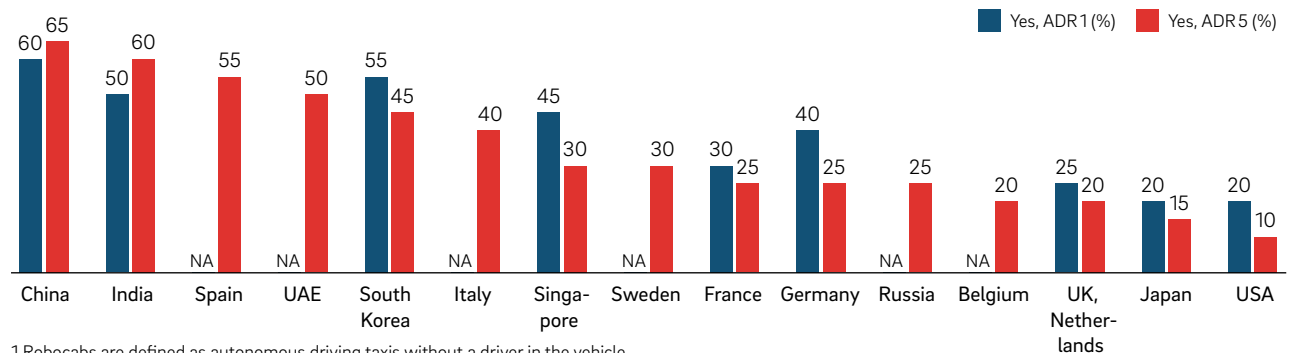
"Would you still buy a car again if fully autonomous robocabs¹⁾ could be used at lower cost per trip compared to your own car?"



Share of potential EV buyers

Overall, there was a fractional fall in the number of people considering buying an EV, but this covered up major slides in some of the big markets

"Are you considering buying a battery electric vehicle as your next car?"



¹ Robocabs are defined as autonomous driving taxis without a driver in the vehicle

Source: ADR survey, Roland Berger

REGULATION

Existing driving laws covering only conventional vehicles are one of the biggest obstacles to autonomous driving. But the ADRs have revealed that countries are getting to grips with the problem. ADR5 shows that most are stepping up efforts to produce regulatory frameworks, and that all except Bahrain and Belgium have basic rules in place to prepare for commercialization.

The UK's Automated and Electric Vehicles Act of June 2018 is the most far-sighted. It includes rules in the key area of AV insurance, helping the UK to join the USA, the Netherlands and Singapore as a legal leader in commercialized autonomous mobility services.

Regulations don't stop at rules of the road, however. Pollution is a major issue for most cities, and many are clamping down on gasoline and diesel vehicles. Of 221 ADR cities analyzed, the number with at least a minor restriction on such vehicles almost doubled to 44% in the past two years.

TECHNOLOGY

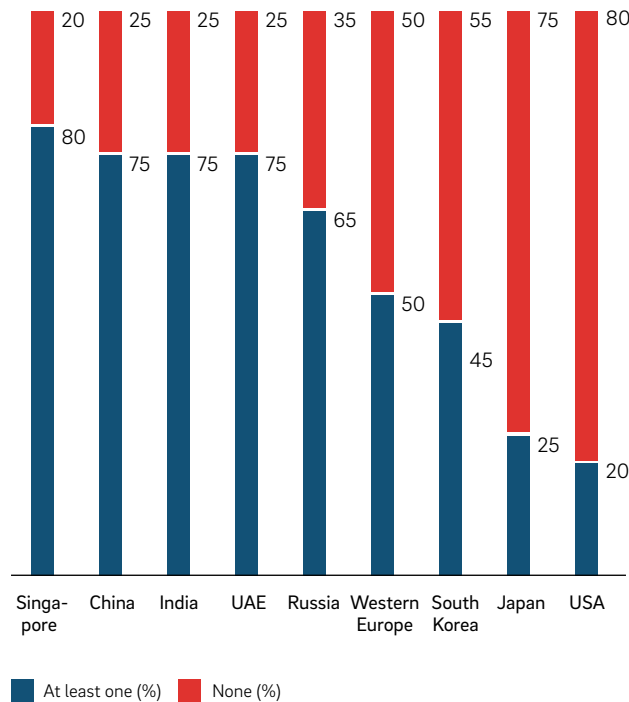
After a peak year for venture capital investments in 2017, with more than USD 21 billion sunk into mobility firms, spending tailed off in 2018. VC investments fell by 38% to USD 13 billion. However, this is still significantly more than was invested in 2015 (USD 10.2 billion) and 2016 (USD 9.3 billion).

Where did it go? While VC investments in mobility services dropped, there was a significant increase in

Share of people knowing at least one person who gave up on cars

Singapore, UAE, China and India show most interest in other mobility concepts

"How many people do you know who did not and don't want to buy a car because they exclusively use other mobility concepts (e.g. car sharing, public transport, taxi, etc.)?"

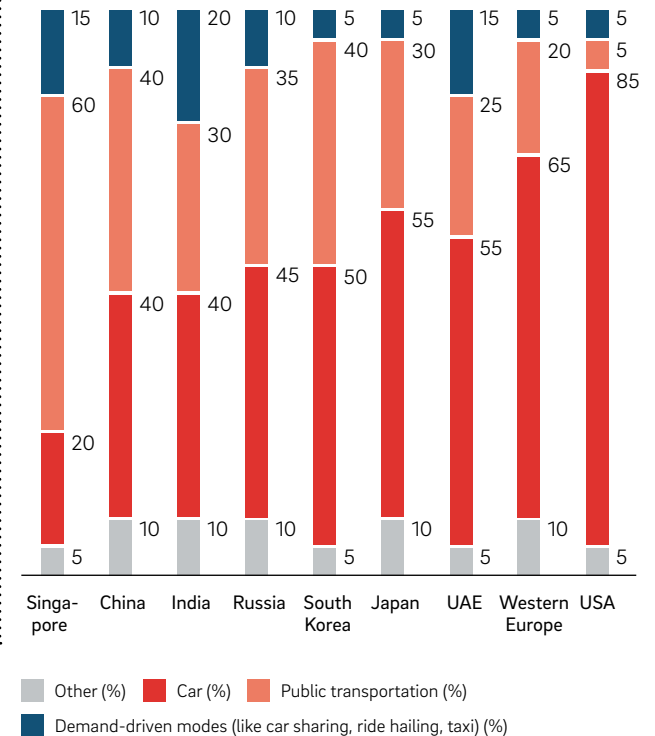


Source: ADR survey, Roland Berger

Share of car driving vs. other modes

US mobility is dominated by car driving – Asian countries and Russia distinctly below Western regions

"Thinking about the last couple of weeks, what % of distance (miles or kilometers) driven did you use which modes of transport for?"



artificial intelligence. Invested capital in the technology, which is crucial to the control of automated vehicles, leaped by more than 900% since 2015 to USD 6.5 in 2018, half of the total VC spend. Bumper funding rounds by China’s deep-learning specialist SenseTime (USD 2.2 billion), AI chipmaker Horizon Robotics (USD 1 billion) and face/speech recognition firm Megvii (USD 0.6 billion) underline how important AI is becoming to the auto industry.

The spending on new technology seems to be worth it. ADR5 shows that in the past two years the number of AV patents registered each year more than doubled – from 1.6% of the total number of auto-related patents registered to 3.8%.

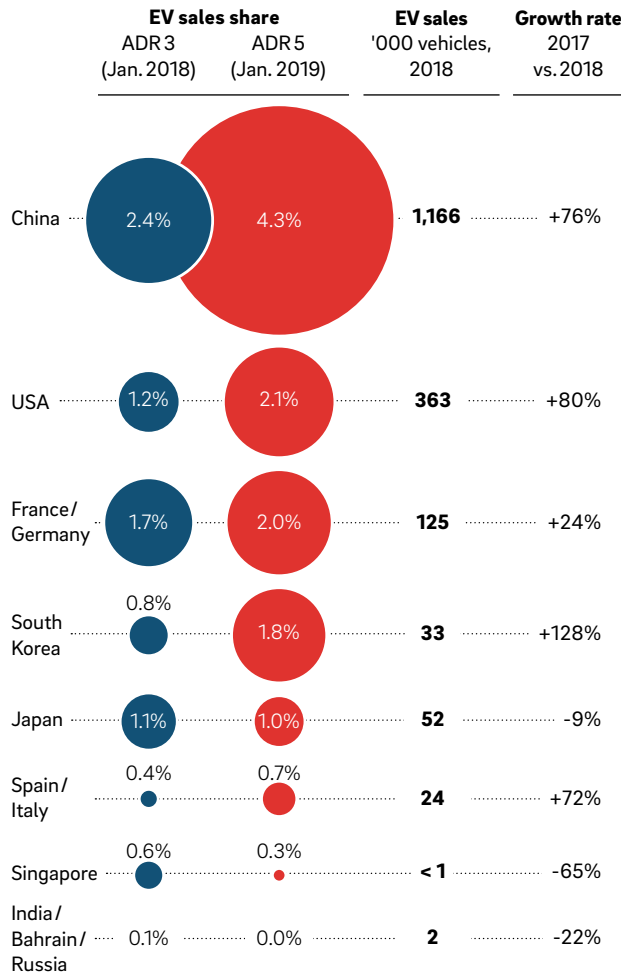
INFRASTRUCTURE

ADR5 reported a mixed picture when it came to infrastructure. While customers are still complaining about the dearth of EV charging infrastructure, the actual growth of public networks progressed well in 2018. South Korea saw a whopping >500% increase in charging stations between 2017 and 2018, from 1 station per 100 km of road to 7 stations, while Dubai and Russia roughly doubled the size of their network and Italy managed a 60% increase. Even established networks enjoyed significant expansion, with India, Germany and China all growing by 30% or more. Customers, however, are likely to demand yet more growth.

There is more satisfaction about the rollout of 5G. The USA and South Korea launched the first commercial services, and several other countries

EV/PHEV¹ sales evolution in last 12 months

EV sales figures have kept increasing globally over the last 12 months

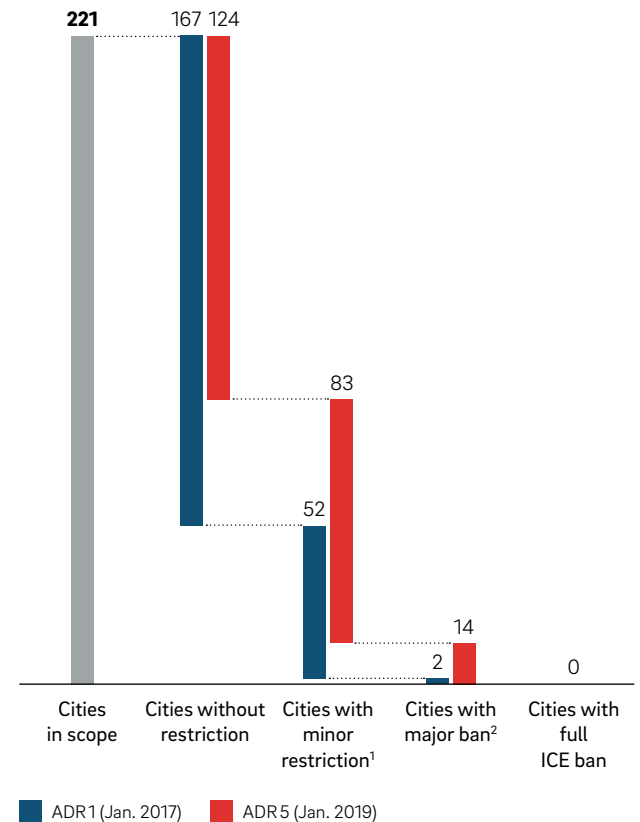


¹ Electric vehicles including plug-in electric vehicles

Source: ADR analysis, Roland Berger

Regulatory evolution for internal combustion engines (ICE) in urban areas

Slow but sure trend in cities coming up with various forms of ICE restrictions in the last 24 months



¹ Ban on vehicles not meeting the latest emission standards (e.g. green badge) or selective actions (e.g. car-free days)

² Clearing the roads of ICEs over a significant timeframe or low chance of being able to register an ICE vehicle

Source: Desk research, Roland Berger

have completed or are nearing the important step of allocating frequencies.

INDUSTRY ACTIVITIES

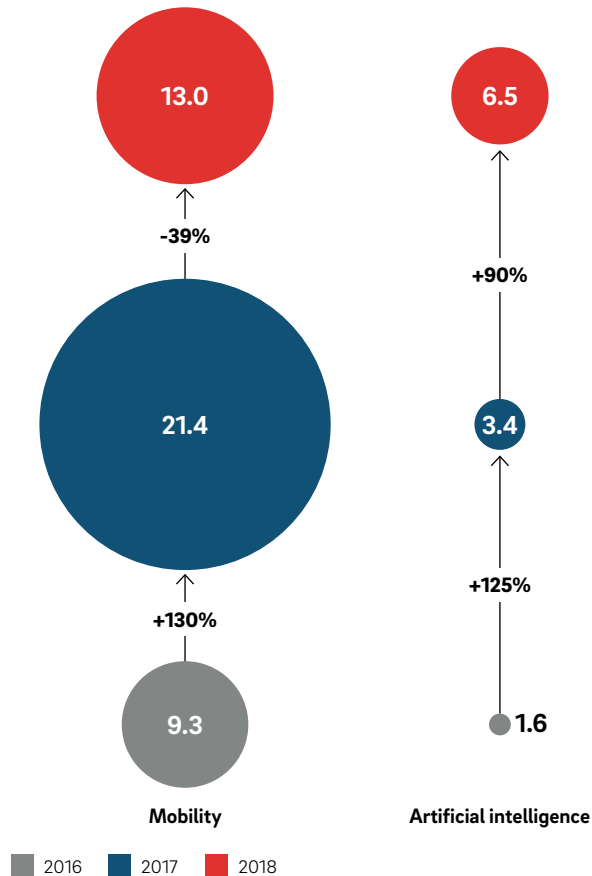
The EV market was the main driver of developments in this dimension. As noted above, EV sales enjoyed a sharp boost in 2018, and a key factor behind this was the growing number of models available. There are currently more than 250 fully electric or hybrid cars on sale, making up 18% of the total vehicle model portfolio. This figure has almost doubled since 2016.

It is expected to rise further as new models with more advanced driver assistance systems – or even autonomous driving functionality – hit the market. ADR indicators bear this out. For example, an ADR5 analysis of LinkedIn profiles showed that the number of full-time employees working in mobility or autonomous driving sectors increased by 29% to more than 65,000. A further rise is expected in the near future as several companies recently announced major investments in R&D.

These include Bosch, the world's largest automotive supplier, which is quadrupling its digital mobility workforce from 1,000 to 4,000 workers by 2021.

Investment in mobility and artificial intelligence¹ (in USD bn)

Huge increase in mobility investments from 2015 to 2017 that slowed down in 2018 – Not for AI businesses, where it almost doubled in 2018

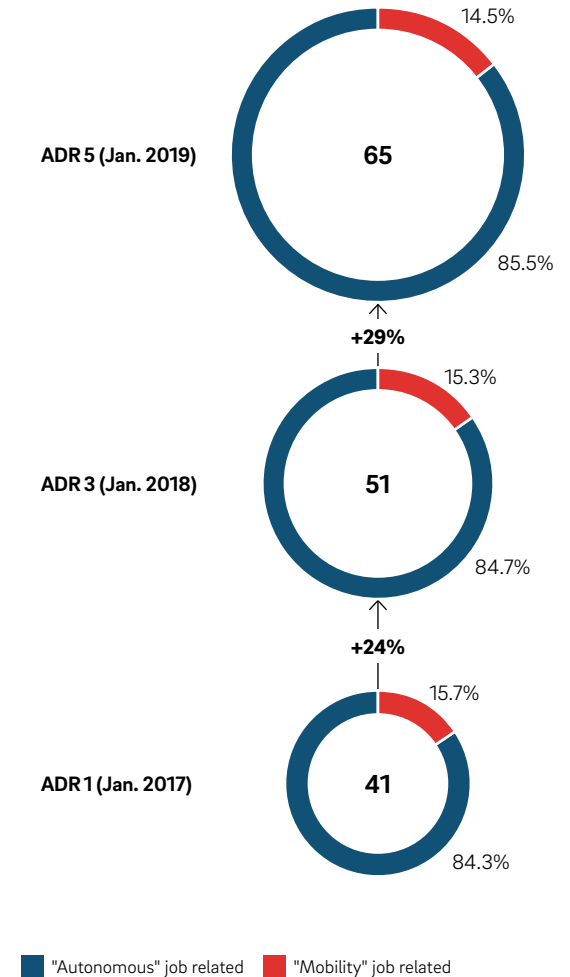


¹ Including investments in smart cars, AI in transportation and autonomous vehicle technologies, and AI infrastructures (natural language processing, computer vision, etc.)

Source: Tracxn, Roland Berger

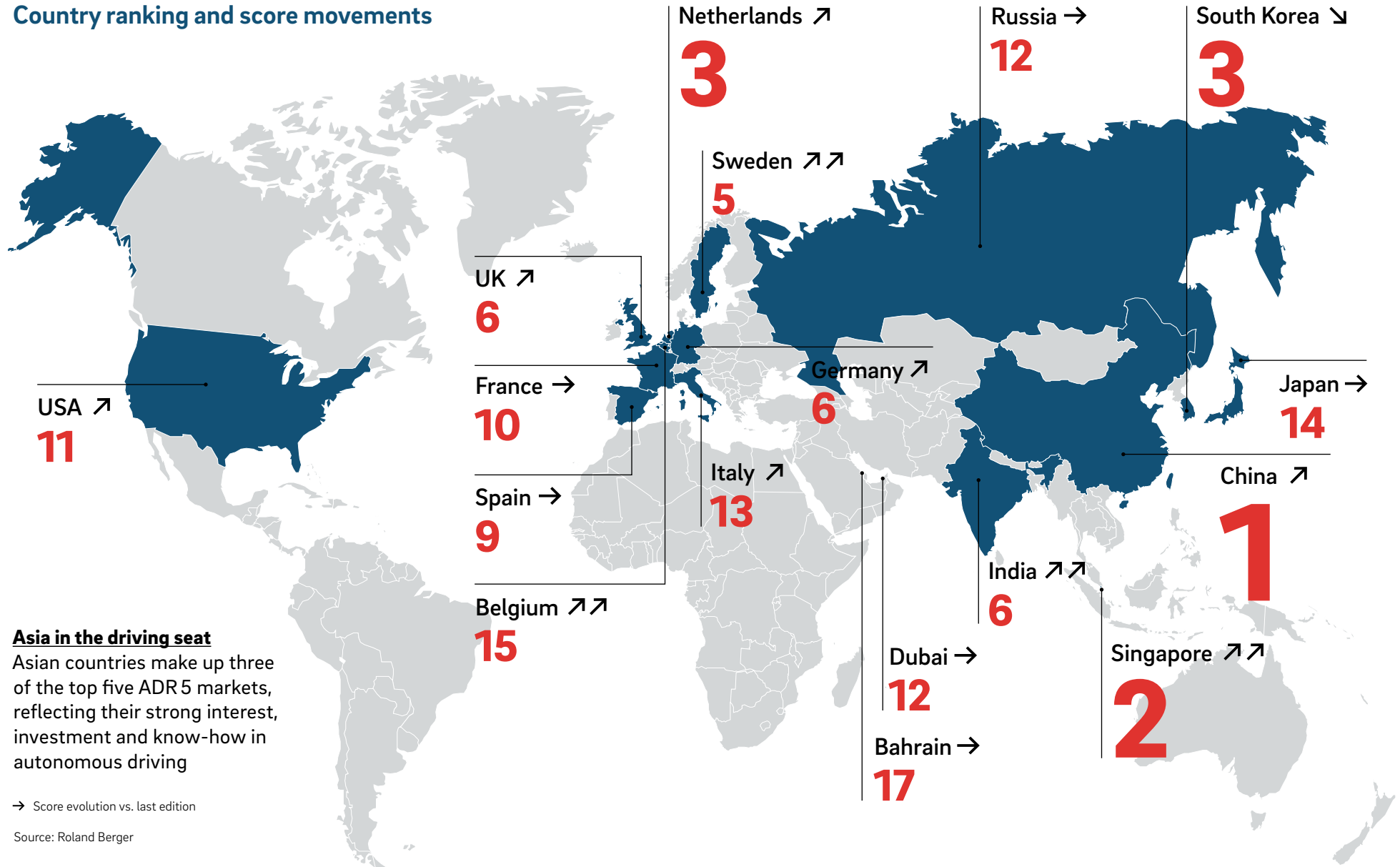
Number of employees listed on LinkedIn ('000)

Continuous increase of R&D resources working on mobility services and autonomous driving



Source: LinkedIn, Roland Berger

Country ranking and score movements



Asia in the driving seat

Asian countries make up three of the top five ADR5 markets, reflecting their strong interest, investment and know-how in autonomous driving

→ Score evolution vs. last edition

Source: Roland Berger

Spot facts by country (score out of 130)

CHINA #1 (77)

- China remains the leader in new mobility models: its car sharing fleet increased by 300% and its ride hailing fleet by 88%. Didi is the market leader
- The country is the world's top EV consumer, with sales increasing by 76% in 2018 to 1.1 million vehicles. This makes up about 60% of total EV sales in the 17 ADR countries

SINGAPORE #2 (75)

- Singapore's fleet of shared vehicles now makes up 19.5% of the total number of vehicles, the highest proportion in the ADR. It has also made significant improvements to public transport and parking in its bid to become a "car-lite society"
- The city-state's 5G rollout is progressing well, with frequencies allocated to telecoms operators Starhub, Singtel and M1

NETHERLANDS #3 (69)

- Dutch EV sales almost tripled to 5.3% of total vehicle sales in 2018 ahead of an upcoming tax break. And the charging network cemented top spot at more than 25 stations per 100km
- Some 55% of Dutch people would give up their car in favor of an autonomous vehicle, above the average

SOUTH KOREA #3 (69)

- South Koreans bought 128% more EVs in 2018 than in 2017 and massively expanded their public charging infrastructure from 1 station per 100km to 7 per 100km
- South Korea became the second country after the USA to launch commercial 5G services. Currently only for businesses, but private users to be added from Q2

SWEDEN #5 (67)

- Sweden's EV sales now top the ADR league at 7% of total sales, but its portfolio of EV models is stagnating at around 13% of all vehicle models
- The country has the highest number of vehicle-to-vehicle enabled models on sale, meaning cars that can "talk" to each other

GERMANY #6 (64)

- While city-center bans on ICE vehicles remain a hot topic, only two actually came into force in 2018. But several others are planned for the beginning of 2019
- In parallel, EV sales are progressing (+23%, now 1.9% of total), coupled with a significant increase in charging station networks (+51% of charging stations since 2017) and model offer (now, more than 18% of total models are EV vs. 13% one year ago)

INDIA #6 (64)

- India doubled the size of its shared vehicle fleet over the past year, from 2.5% of the total number of vehicles on the road to 5%
- Indians also like the sound of EVs, with the number considering buying an EV at 60%. But actual EV sales are still very low at less than 0.1% of total vehicle sales

UK #6 (64)

- The UK took a big step towards becoming a leader in autonomous driving with its Automated and Electric Vehicles Act, although it still requires supporting legislation
- The country saw unspectacular but solid growth in EV sales, rising by a quarter to 2.2% of total sales

SPAIN #9 (63)

- An ADR newcomer, Spain has the largest range of EV models among the 17 countries, with electric cars accounting for 20% of models for sale. But EVs make up just 0.9% of total sales
- The country made great progress in 5G, with frequencies allocated to firms including Vodafone (in coalition with Huawei) and a planned launch date of 2020

Spot facts by country (score out of 130)

FRANCE #10 (62)

- France took a major step forward on AV regulation, passing the PACTE Law in October. It limits AV risks and improves testing rules, with full commercialization expected in 2022
 - Growth in EV sales wasn't as spectacular as elsewhere, but France, a major market, still recorded a respectable rise of about a quarter to 2% of total sales in the past year
-

USA #11 (61)

- Overall, car ownership is still important in the USA, but views among the young are changing fast: 40% of 18-29-year-olds would now give up cars for robocabs, as against 25% two years ago
 - The US became the first country to launch commercial 5G services, starting with Verizon's Home in October 2018 and AT&T's City Networks in December
-

DUBAI #12 (60)

- A newcomer to the ADR, Dubai had a similar mobility profile to China and Singapore, e.g. 75% of people know at least one person who uses modes of transport other than their own car
- Dubai is investing heavily in its EV network: the number of charging stations doubled in the past 12 months from 100 to 200, placing Dubai second in the ADR

ITALY #13 (59)

- Sales of EVs in Italy may still be low but growth has been spectacular, from 0.2% in 2017 to 0.5% in 2018. More than 60% growth in its charging network probably helped
 - Regulatory preparations are progressing well: basic regulations were put in place in 2018 and two test tracks opened during the year
-

JAPAN #14 (58)

- Japan's Toyota has become the only non-premium car brand to offer V2V equipped models, although these are only available in Japan for now
 - But the country's EV indicators are stagnating: EV sales stuck at 1% of total; interest in EVs down from 25% a year ago to 15%; and charging network with only 2.8 stations per 100 km
-

BELGIUM #15 (57)

- Belgium has thrust itself back into the AV game with an official royal decree now allowing AV tests, and the opening of two official test tracks
- However, EVs are falling in popularity: interest in the cars dropped from 35% of potential customers a year ago to 20% now, and sales flatlined at around 2.2% of the total

RUSSIA #15 (57)

- Russia put an end to its erratic AV testing environment by introducing new regulation and official testing standards, plus designating three official test tracks
 - The country also vastly increased its EV charging network, expanding it by 85% in the past six months alone
-

BAHRAIN #17 (56)

- Bahrain, another ADR newcomer, wants to become one of the first countries in the world to install a full 5G network, and is working with Huawei on it. But plans are still at an early stage
- However, interest in AVs doesn't match this ambition: only 35% of Bahrainis would give up their car to use a robocab service

What is the Automotive Disruption Radar?

The Automotive Disruption Radar is a biannual analysis of market trends related to disruption in the global automotive industry. Its latest findings are based on field research and a survey of 16,000 car users across 17 markets (Bahrain, Belgium, China, UAE (Dubai), France, Germany, India, Italy, Japan, Netherlands, Russia, Singapore, South Korea, Spain, Sweden, UK, USA). ADR 5's 26 indicators are grouped into five dimensions:

- **Customer interest:** Do people want autonomous vehicles and to what extent?
- **Regulation:** What are the regulatory conditions?
- **Infrastructure:** How developed is the infrastructure for autonomous vehicles?
- **Technology:** How far advanced is the technology for autonomous driving?
- **Industry activities:** Which solutions have been announced or already exist?

THE AUTOMOTIVE DISRUPTION RADAR PROVIDES GUIDANCE

The ADR aims to answer key questions such as: which factors are driving change in automotive ecosystems; how do these factors evolve over time; and what can decision makers do to best manage disruption? Beyond the survey, information is also drawn from external sources such as leading mobility experts and major industry reports. Ultimately, the ADR is a go-to decision-making tool for senior executives in the mobility sector.

Each nation is scored along the 26 indicators. This framework allows us to conduct a fact-based measurement to try to determine which nation is most likely to introduce autonomous mobility first.

FIVE ADR ISSUES WITH FINDINGS FROM THE SURVEYS HAVE BEEN PUBLISHED SO FAR



ADR 1

January 2017¹
Tracking disruption signals in the automotive industry



ADR 2

July 2017¹
Asia ahead. Have major Western European markets already lost the race for future mobility?



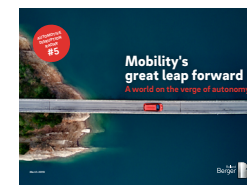
ADR 3

January 2018¹
Mobility services move up a gear



ADR 4

July 2018¹
China speeds ahead



ADR 5

January 2019¹
Mobility's great leap forward. A world on the verge of autonomy

¹ Date of data collection

List of all indicators and measures



○ Indicators ○ Measures

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FOR MORE INSIGHTS INTO OUR ADR FIGURES AND ANALYSIS

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Automotive Disruption MADE by RB

We believe that the combination of 4 dimensions (Mobility, Autonomous driving, Digitalization and Electrification) is likely to trigger a major disruption in the automotive industry over the next 15 years. Since 2016, we have been bringing together our experts from all around the world to try to make this new future and its implications more concrete, and to best support the key decision makers of the automotive industry.