2020 Autonomous Vehicles Readiness Index

Assessing the preparedness of 30 countries and jurisdictions in the race for autonomous vehicles

KPMG International

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Quick reader guide

The *Autonomous Vehicles Readiness Index* (AVRI) is a tool to help measure the level of preparedness for autonomous vehicles across 30 countries and jurisdictions. It is a composite index that combines 28 individual measures from a range of sources into a single score. More information on the results, methodology and sources used can be found in the Appendix.

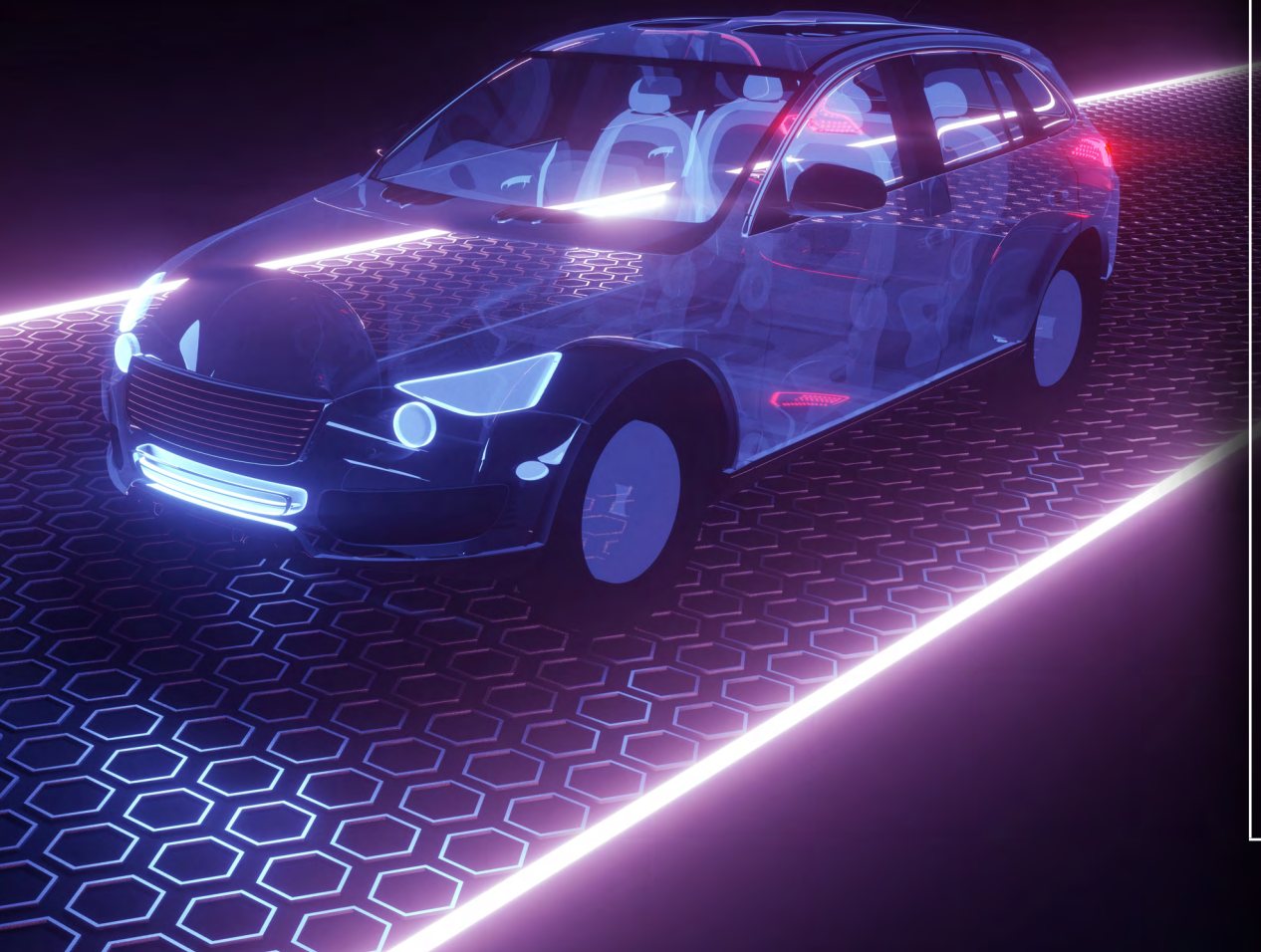
The intended core audience for the AVRI is public sector organizations with responsibility for transport and infrastructure. It should also be of interest to other public and private sector organizations that are involved with, or make use of, road transport.

This report uses the term 'autonomous vehicles', abbreviated to AVs, to refer to the technology used both within vehicles and externally, such as digital networks and road infrastructure. It also uses AVs to refer to vehicles that can do everything a traditional vehicle does without human intervention, sometimes described as 'level five automation', where vehicles are fully self-driving and the human driver becomes a passenger.

The terms AV and driverless car are used interchangeably, although this report also covers autonomous buses and trucks. The following abbreviations are also used in the text: AI for artificial intelligence, EV for electric vehicle(s), lidar for light detection and ranging technologies and IoT for Internet of Things.

US dollar equivalents for local currencies are as of early June 2020.

Index results



Country or jurisdiction	Rank 2020	Rank 2019	2020 score
Singapore	1	2	25.45
The Netherlands	2	1	25.22
Norway	3	3	24.25
United States	4	4	23.99
Finland	5	6	23.58
Sweden	6	5	23.17
South Korea	7	13	22.71
United Arab Emirates	8	9	22.23
United Kingdom	9	7	21.36
Denmark	10	n/a	21.21
Japan	11	10	20.88
Canada	12	12	20.68
Taiwan	13	n/a	19.97
Germany	14	8	19.88
Australia	15	15	19.70
Israel	16	14	19.40
New Zealand	17	11	19.19
Austria	18	16	19.16
France	19	17	18.59
China	20	20	16.42
Belgium	21	n/a	16.23
Spain	22	18	16.15
Czech Republic	23	19	13.99
Italy	24	n/a	12.70
Hungary	25	21	11.66
Russia	26	22	11.45
Chile	27	n/a	11.28
Mexico	28	23	7.42
India	29	24	6.95
Brazil	30	25	5.49

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Foreword

Richard Threlfall
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Bio

When we first published the *Autonomous Vehicles Readiness Index* in 2018, there was widespread excitement around the technology, reflected in frequent media coverage. This has since reduced significantly and the casual observer could conclude that perhaps it was all hype after all, and that the autonomous revolution remains decades away.

The reality however is that AV technology is entering a period of development maturity, during which the complex challenges of implementation are being addressed. The transformational potential of AV technology remains immense.

According to the data gathered for the third AVRI and insights from specialists within KPMG's network of national firms, significant progress has been made on the extensive work needed to allow AVs to operate safely and effectively in our societies, including overhauling regulations and running large-scale tests. We are also seeing AVs move into use around the world in public transport and in closed-site environments such as mining and logistics. And national and local governments are finding distinctive ways to introduce them.

This edition of the AVRI adds five new countries and jurisdictions: Belgium, Chile, Denmark, Italy and Taiwan. It lightly refreshes the measures used to assess each country and jurisdiction to account for our increased understanding of some of the key enablers of AVs, such as telecommunications. The indicators remain organized by the same four pillars as the first two reports — policy and legislation, technology and innovation, infrastructure and consumer acceptance.

As some countries and jurisdictions devolve responsibility for transport to local authorities, this year's report also features coverage of five notable cities — Beijing, Detroit, Helsinki, Pittsburgh and Seoul — which are undertaking ground-breaking work at a municipal level.

The third AVRI sees Singapore swap places with the Netherlands to claim the top position in the index. Since the start of 2019 the city-state has taken a number of significant steps to encourage the testing, development and adoption of AVs, such as opening a tenth of its roads for testing. Like several other highly-ranked countries, Singapore has embedded AVs into wider goals, including greater use of public transport, wider use of EVs and economic development from research-focused jobs.

As in previous editions, many national scores are very close and many countries and jurisdictions have opportunities to make progress. Demonstrating this, of the 25 in the 2019 index, 17 have increased their score. By providing assessments of strengths, challenges and recommendations, this report aims to provide constructive insights that can help governments learn from each other and improve.

The coronavirus pandemic has led to several AV trials being suspended, but it is possible to imagine the contribution this technology could make if it were further developed, from maintaining delivery networks to providing more flexible, less crowded public transport such as through the use of smaller, on-demand minibuses.

I continue to see AVs as enabling an impending revolution that will strengthen our societies and economies, while making the world's roads safer and more accessible to everyone.

Introduction: Enabling the AV revolution

This third edition of the *Autonomous Vehicles Readiness Index* shows that over the last year countries and jurisdictions have been grappling with the key policy and investment decisions needed in order to enable the AV revolution. Some differences have emerged in proposed approaches, but countries and jurisdictions are also learning from each other and engaging with the automotive companies and technology businesses that are developing the technology, as KPMG recommended in the first index.

Key enablers include safety, privacy, digital infrastructure, impact on transport systems and cross-border travel. We consider each in turn.

Safety

The World Health Organization estimates that there are 1.35 million road deaths and 50 million injuries annually. With human error responsible in around 95 percent of cases, AVs have the potential to reduce these casualties dramatically. At a global ministerial conference on road safety held in Stockholm in February 2020, participants recognized that "advanced vehicle safety technologies are among the most effective of all automotive safety devices" and called for countries to ensure that all vehicles sold by 2030 include safety performance technology.[1]

Although AVs are much safer than human drivers, governments are understandably concerned to ensure that AV technology is as safe as possible. At the conference

the Swedish government emphasized the 'Vision Zero' approach it adopted in 1997, which aims that no-one is killed or suffers lifelong injuries from road traffic accidents.[2] In apparent criticism of vehicle makers rushing vehicles with limited autonomy to market, Hakan Samuelsson, the chief executive of Swedish-based vehicle maker Volvo, said in March 2019: "We have a responsibility and everybody who's in this business has that responsibility, because otherwise you're going to kill a technology that might be the best lifesaver in the history of the car."[3]

Sweden's safety-focused approach will almost certainly be followed by most other authorities. The outcry following the tragic death of a pedestrian in Phoenix, Arizona who was killed by an AV in 2019 shows that society has a very low tolerance for accidents caused by technology, and governments will set policy accordingly. But there is a risk that setting the safety bar too high for AVs will slow their introduction and lead to many more people dying on roads from human error in the meantime.

Privacy

AVs present a particular dilemma around data privacy. For public authorities, one of the great opportunities of connected vehicles is the optimization of road capacity. If they know the position and destination of all vehicles in a particular area, an intelligent traffic management system can set the speeds and routes of all these vehicles in order to minimize journey times and congestion levels. But doing so requires vehicle tracking and sharing of personal information in a way which in many cultures is currently regarded as politically unacceptable. Some companies may also be wary of involvement in such work for similar reasons.

Countries already diverge significantly over the extent to which they protect the privacy of road users. The European Union has strict privacy standards as a result of the General Data Protection Regulation (GDPR).

The United States provides less protection at a federal level, although states including California have recently tightened their rules. Some countries including China place less importance on privacy as a result of a more communal approach.[4]

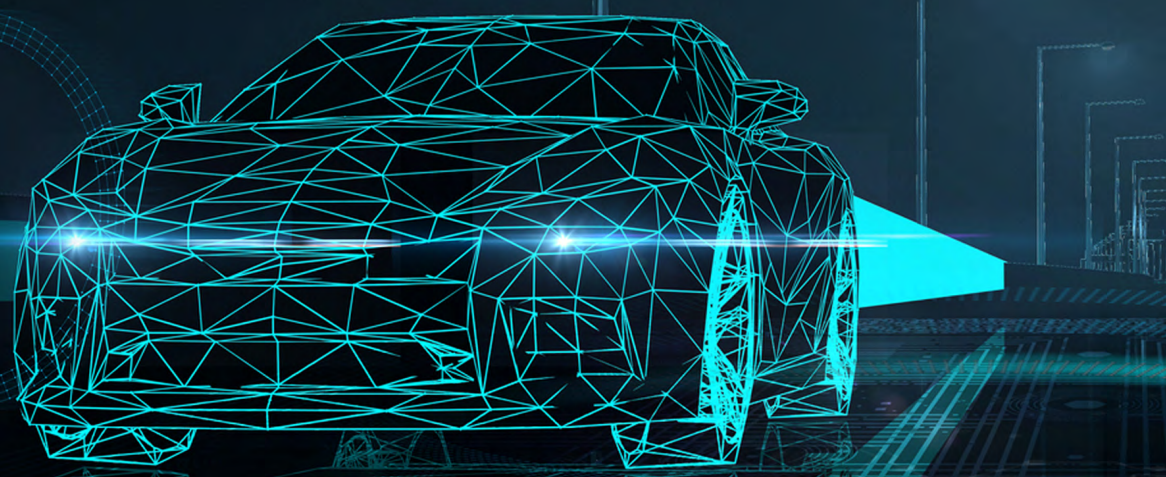
This means the data that AVs and other connected vehicles collect and transmit is likely to vary substantially from country to country. For those with strict data protection rules, vehicles will need to anonymize data and minimize what is passed on, while other jurisdictions may require AVs to tell the authorities where they are at all times. KPMG anticipates however that over time the majority of countries will move to some form of data collection from connected vehicles in order to ensure the most efficient use of road space.

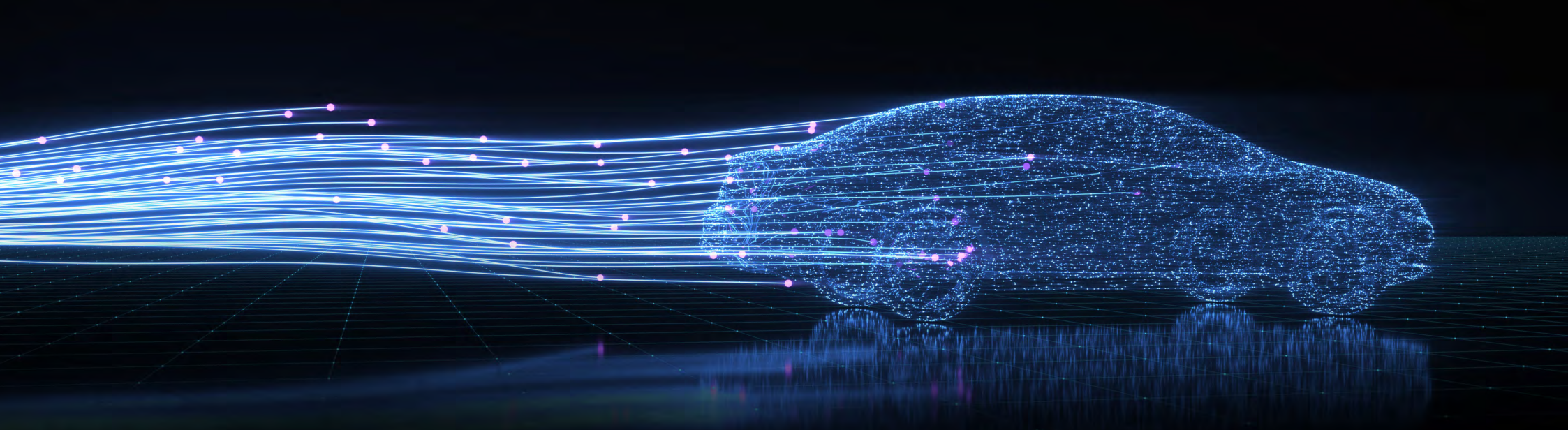
Digital infrastructure

There is debate over how much effort countries and jurisdictions should put into digital infrastructure for AVs, including sensor networks, roadside equipment such as smart traffic lights that can tell AVs when to stop or go, and high-quality digital mapping.

Level four AVs, which are only capable of autonomy in certain conditions, may be 'geo-fenced', or geographically limited, to areas with adequate digital infrastructure. "We overestimated the arrival of autonomous vehicles," said Ford's chief executive officer Jim Hackett in April 2019, adding that the company's first AV was still planned for 2021 but "its applications will be narrow, what we call geo-fenced, because the problem is so complex".[5] But if this generation of AVs require sensors, on-road equipment and detailed mapping to work well, their popularity and use will be limited to areas that can afford and have invested in such infrastructure.

From a safety point of view, level five AVs should not need to rely on external infrastructure to operate. However their safety is likely to come at the cost of efficiency, with a number of studies suggesting slower traffic speeds and worse congestion with AVs because they will drive more defensively than humans. Digital infrastructure, allowing vehicle-to-infrastructure (V2I) communication, is potentially the solution to this. V2I systems use a centralized traffic management system to optimize the use of a region's highways by orchestrating how vehicles operate for the benefit of all users.





This means potentially different AV operating scenarios. In areas where road capacity is unconstrained, for example in rural areas, AVs may rely more on their own systems. In areas where capacity is constrained, for example in cities and on major highways between cities, it will be more important for governments to invest in digital infrastructure and require AVs to interface with the systems they establish.

Impact on transport systems

The highest-profile work on AV development, led by technology companies based in the US, has focused on driverless private cars and taxi services. If these predominate, the result is likely to be more vehicles on roads. However, many countries and jurisdictions are using AVs to increase the convenience and popularity of shared transport. This includes trials and regular services of slow-moving driverless minibuses in countries including Chile, Denmark, Finland and Norway. Spain is trialing such vehicles for tourism in an environmentally sensitive area of the Canary Islands while Australia is using them in a retirement village.

This focus on public transport is gradually being scaled up, with operators in Singapore, Spain and the UK testing full-length autonomous buses. This will reduce the need for professional drivers. The transport department of Taipei in Taiwan is planning to start on-road trials of AV buses at night to help solve a driver shortage, and bus drivers in Singapore are being retrained as bus safety operators under the city-state's plan to introduce driverless buses from 2022. As AVs cut labor costs, they make services for remote communities more affordable, as well as allowing better public transport in crowded cities.

The coronavirus pandemic could also boost the case for the adoption of AVs. The disease has made shared vehicles less attractive to users, but a regularly-cleaned publicly-managed AV minibus might look like a better option than a vehicle from a private ride-hailing service. In other industries, the pandemic has increased both demand and opportunity for automation, and in a few cases AVs have been brought into use for this reason.[6] They have generally been used to make deliveries rather than transport people, such as healthcare provider Mayo Clinic and Florida's Jacksonville Transportation Authority using four AVs to move tests from a drive-through location to a lab, with no human supervision on isolated routes.[7]

Traveling across borders

Although countries and jurisdictions may differ in how much digital infrastructure they deploy for AVs, they should ensure it works for any vehicle that is likely to use it. This means international standardization to allow AVs to operate in other countries, at least within the same continent. Within the European Union, some basic automation will become mandatory in all new vehicles under the Advanced Driver Assistance Systems (Adas) from 2022, including autonomous emergency braking and assistance in staying in lanes. It would make sense for similar international standardization to cover V2I.

The same is true of insurance. Some countries have already legislated to clarify liability in relation to AVs, including the UK's Automated and Electric Vehicles Act. But with such vehicles potentially capable of moving autonomously across national borders, it would be helpful to have a degree of consistency in legislative approach.

The international community is not always a model of co-ordination, as the coronavirus pandemic and climate change are demonstrating. However, despite significant differences in what countries and jurisdictions want to achieve with AVs, there are plenty of areas where all can benefit from an aligned approach.

Milestones

January 2019
The Consumer Electronics Show in Las Vegas sees Daimler Trucks unveil its Freightliner Cascadia, the first truck in North America to include automated assistance.[8]

February 2019
President Tsai Ing-wen opens the Taiwan CAR (connected, autonomous and road-test) Lab in Tainan, its first closed testing ground for AVs.[9]

March 2019
Austria allows users to take their hands off the steering wheel when driving within one lane on a highway and operate self-parking systems when outside the vehicle.[10]

April 2019
The City of Espoo in Finland begins public operation of the all-weather Gacha driverless bus, designed by local company Sensible 4 and Japanese retailer Muji.[11]

May 2019
A driverless electric truck built by Swedish AV startup Einride takes its first drive on a public road between a warehouse and a terminal in Jönköping.[12]

June 2019
Apple buys Drive.ai, a Silicon Valley-based startup that has piloted AV technology that can be fitted to existing vehicles.[13]

July 2019
Residents of a retirement village in Coffs Harbour, New South Wales, get access to an on-demand AV minibus service called BusBot, summoned using a smartphone app.[14]

August 2019
UK testing organization Zenzic, which is funded by industry and government, opens a funding competition for studies on the cybersecurity of AVs.[15]

September 2019
Shanghai becomes the first Chinese city to issue permits making it easier to test AVs on public roads, to vehicle-makers SAIC and BMW and ride-hailing company Didi Chuxing.[16]

October 2019
Singapore's government opens one-tenth of its total road network for AV testing and starts retraining 100 bus drivers as safety operators.[17]

November 2019
Russian technology company Yandex said it has started road-testing small autonomous robots known as Yandex Rovers that are designed to make local deliveries in cities.[18]

December 2019
Waymo buys Latent Logic, a machine learning-focused company that had been spun-out from Oxford University's Department of Computer Science.[19]

January 2020
General Motors' Cruise AV division unveils the Origin, a purpose-built self-driving car designed for ride-sharing with no physical driving controls and room for six passengers.[20]

February 2020
The Spanish government announces a new mobility law that will cover AVs as well as more EV charging points, although details have since been delayed by the coronavirus crisis.[21]

March 2020
US ride-hailing company Uber resumes testing of AVs in its home city San Francisco, two years after one of its vehicles was involved in a fatal accident in Arizona.[22]

April 2020
Japan's Road Transport Vehicle law comes into force, including legal recognition of AVs, an inspection regime and a permit system.[23]

May 2020
US technology company Intel buys Moovit, an Israeli startup which provides an urban mobility app, for around US$900 million, to support its Israeli-based AV unit Mobileye.[24]

June 2020
Germany vehicle makers BMW and Mercedes-Benz put on hold a partnership involving around 1,200 people that was developing shared technology for level 4 AVs.[25]

Executive summary

Methodology

The 2020 edition of the AVRI assesses 30 countries and jurisdictions. This includes the addition of five new countries and jurisdictions to the roster from 2019, and can explain some of the downward movement of some countries as a result. The AVRI uses 28 different measures, organized into four pillars: policy and legislation, technology and innovation, infrastructure and consumer acceptance. Four of the variables are scored for this index by KPMG International and ESI ThoughtLab and 24 draw on existing research by KPMG International and other organizations. Full details are in the Appendix.

P. 12

Singapore

1st

- For the first time Singapore leads the AVRI, overtaking the Netherlands for the top-ranked position and leading on both the consumer acceptance and policy and legislation pillars.
- The city-state has expanded AV testing to cover all public roads in western Singapore and aims to serve three areas with driverless buses from 2022.
- The number of charging points will increase from 1,600 to 28,000 by 2030 with incentives for buying EVs, although the government is also phasing in a usage tax to compensate for loss of fuel excise duties. Given they will be mostly electric, such moves are vital in enabling AV implementation.

P. 13

The Netherlands

2nd

- The Netherlands retains top ranking on the infrastructure pillar, leading on EV charging stations per capita and second only to Singapore on road quality.
- An extensive series of pilots means that 81 percent of people live near AV testing sites. However, tests on truck platooning in July 2019 found challenges in keeping vehicles connected at all times.
- 2019 saw the Netherlands extending its use of smart road furniture, including traffic lights that send their statuses wirelessly to AVs in 60 new areas of the country.

P. 14

Norway

3rd

- Norway extended its use of AVs in 2019, with several bus routes in Oslo now driverless, and the speed limit for driverless vehicles on roads increasing from 16kph to 20kph.
- A majority of passenger vehicles bought in Norway in 2019 were battery or plug-in hybrids, as a result of high taxes on internal combustion vehicles and fuels and subsidies for EVs.
- The country is testing AVs in extreme weather, with pilots of driverless trucks, cars and buses on the snow-bound Svalbard islands in the Arctic Circle.

Also noted

— South Korea climbs six places to 7th in this edition of the AVRI, the biggest rise of any country. The government published a national strategy for AVs in October 2019, with the goal of reducing road deaths by three-quarters.

— The UK leads on a new AVRI measure of cybersecurity, with AV testing body Zenzic funding seven projects in this field.

— Israel retains its leadership of the technology pillar, leading on both AV-related companies and investments scaled by population.

New to AVRI

— Denmark is the highest-rated of the five countries and jurisdictions joining this edition of the AVRI, occupying the 10th spot. It allows AV tests on any public road and its first driverless bus service started running in March 2020 in Aalborg.

— Taiwan, the second highest at 13th, has a focus on testing AVs on its challenging mixed-use roads. Taipei is planning to start a night-time trial of driverless buses partly to tackle a shortage of drivers.

— Belgium, entering at 21st, ran its first demonstration of an AV bus at Brussels airport in May 2019, operated by Flemish regional transport authority De Lijn.

— Italy, placed 24th, introduced rules and an observatory for AV testing in 2018, with tests beginning in Parma and Turin in 2019.

— Chile, at 27th, has made use of AVs in mining for several years and in January 2020 started Latin America's first public pilot in a park in central Santiago.

P. 15

United States

— The US is second only to Israel on technology and innovation, with 420 AV company headquarters, 44 percent of all of those tracked in this research.

— American technology companies, including Apple and Google's Waymo unit, and vehicle makers such as General Motors and Ford, continue to dominate AV development. GM's Cruise division unveiled the Origin, a purpose-built self-driving car designed for ride-sharing.

— Cities including Detroit and Pittsburgh are undertaking innovative work to introduce and promote AVs (both are profiled in the Cities to watch section).

P. 16

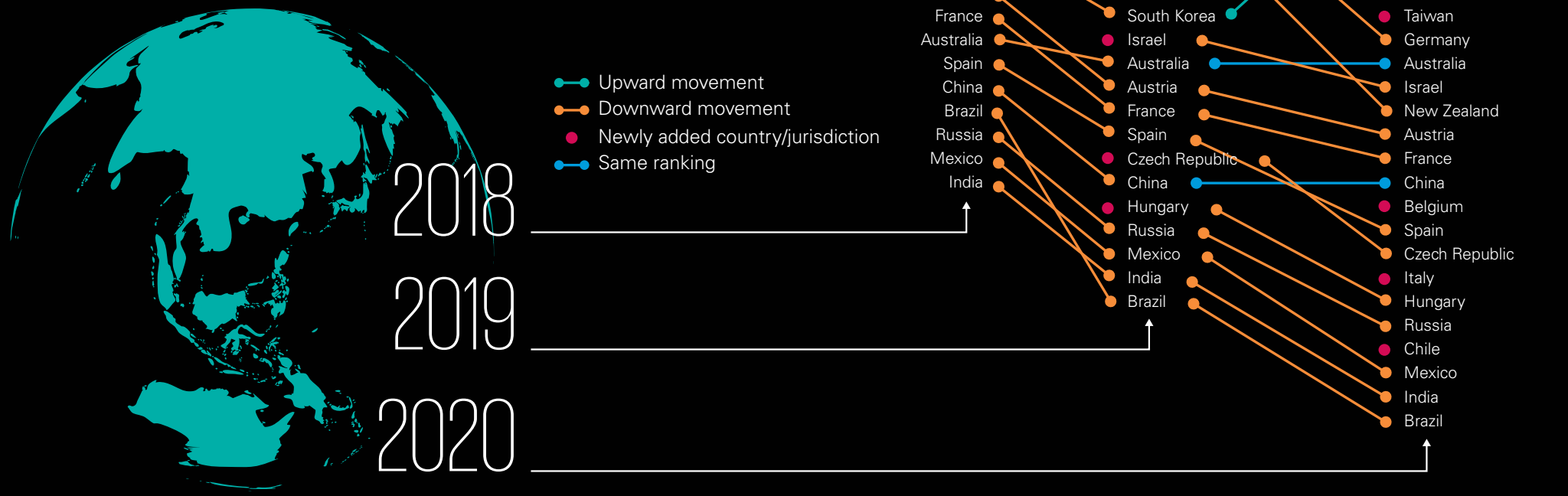
Finland

— Finland has the highest ratings for AV-specific regulations and for the efficiency of its legal system in challenging regulations, and its entire road network is open for AV trials.

— Helsinki (profiled in Cities to watch) and its neighbor Espoo both run public AV bus services, with the latter using an all-weather vehicle designed by local company Sensible 4.

— Finland also leads on measures of digital skills, benefiting from a breadth of talented engineers, many of whom have notable experience having been part of Nokia's legacy. It also makes the greatest use of ride-hailing services.

Comparative AVRI positions from 2018 to 2020



National profiles

Policy and legislation

Technology and innovation

Infrastructure

Consumer acceptance

1 | Singapore

1 Policy and legislation
11 Technology and innovation
5 Infrastructure
1 Consumer acceptance

Singapore's top rating on policy and legislation reflects the further efforts it has taken to encourage the use of AVs. In January 2019, the city-state's government published its TR68 draft national standards for such vehicles as well as a voluntary AI governance framework, with the latter updated in January 2020 with real use-cases and consideration of how AI must generate consistent results.[26]

AV test sites in most countries and jurisdictions are either closed or tend to occupy relatively small areas, but in October 2019 Singapore expanded its testing area to cover all public roads in western Singapore, around 1,000 kilometers (620 miles) making up one-tenth of the city state's total.[27] It also started retraining 100 bus drivers as AV bus safety operators, as part of its target to serve three new towns with driverless buses from 2022. March 2019 saw Volvo launch a 12-metre AV electric bus with Singapore's Nanyang Technological University, which could be used to serve these areas. Such work is supported by Singapore's excellent road infrastructure, rated the best in the world in the World Economic Forum's *Global competiveness report*.

Singapore's February 2020 budget included S$6 million (US$4.3 million) to support AV test-beds. With the aim of phasing out all internal combustion engine vehicles by 2040, it pledged to expand the number of EV charging points from 1,600 to 28,000 by 2030. An EV early adoption incentive scheme running until December 2023 cuts the purchase cost of such vehicles by an average of 11 percent.[28] While the budget has cut annual road taxes for EVs, it also started phasing in a usage tax of S$700 (US$500) a year for fully-electric vehicles, in advance of a distance-based usage tax to compensate for the loss of fuel excise duties.[29] "I think Singapore is ahead of the curve in thinking through the budget consequences of EVs," says Satya Ramamurthy, Partner, Head of Infrastructure, Government and Healthcare, KPMG in Singapore and Indonesia.

March 2020 saw South Korean vehicle maker Hyundai announce a global innovation center that will open in Singapore in 2022, while Chinese vehicle electronics company Desay has set up its first overseas research and development center to work on AVs. However, UK consumer manufacturer Dyson cancelled its plans to open a factory for EV vehicles in Singapore.

Ramamurthy says that the country's market size makes it difficult to attract vehicle manufacturing, but it has major strengths including people's acceptance of new technologies, recognized by its leadership of the consumer acceptance pillar. AVs are also expected to be integrated into Singapore's land transport master plan for becoming a '45-minute city' with 90 percent of journeys completed in this time by 2040.[30] Private AV ownership is not the priority: "That is consistent with the 'car-lite' policy of Singapore. AV adoption and development will be significantly focused on freight movement and public transport in the first instance, rather than for personal transport."

Quality of roads top five

Source: World Economic Forum, *Global competiveness report* (2019)

> "AV adoption and development will be significantly focused on freight movement and public transport in the first instance, rather than for personal transport."
>
> **Satya Ramamurthy**
> Partner, Head of Infrastructure, Government and Healthcare
> KPMG in Singapore and Indonesia

2 | The Netherlands

3 Policy and legislation
10 Technology and innovation
1 Infrastructure
7 Consumer acceptance

The Netherlands, which led the first two editions of the AVRI, slips to second place overall, although it retains numerous strengths. These include one of the strongest performances on policy and legislation, being one of four countries receiving the highest score for AV regulations and among the highest ratings on government-funded AV pilots. An extensive series of such pilots means that 81 percent of people live near to testing, second only to Singapore.

However, following significant announcements in 2018 including a legal framework for AVs, the last year has seen the Netherlands finding challenges involved in introducing AVs — working through these is an essential step in successful adoption. It continued with tests on truck platooning in 2019, which demonstrated problems in keeping vehicles connected at all times. Similarly, attempts by the government to test and award an AV a driving license have not been successful.

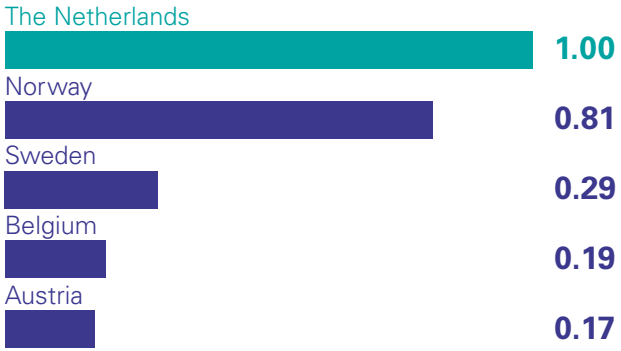
"Although AVs are already quite sophisticated, the time that is needed to solve the 'edge-cases' to make it work in real life, will probably hold-off the introduction of self-driving solutions on our public roads any time soon," says Stijn de Groen, Lead for Mobility 2030, KPMG in the Netherlands. If we already want to benefit from AV solutions, it could involve using vehicles in closed areas or considering dedicated roads or lanes, although these can be hard to introduce in areas with high population densities.

The Netherlands retains leadership of the infrastructure pillar, leading on EV charging stations per capita with three per thousand people, and is second only to Norway on EV market share, with 15 percent of new cars being battery-powered or hybrids. Performance on EVs is included in the index as most AVs are electric, meaning that it would be very difficult for a country to introduce driverless vehicles without having already established infrastructure for electric ones. The Netherlands is also second only to Singapore on road quality, again with good roads being a prerequisite for AV introduction.

On specific AV infrastructure work, 2019 saw the country extending its use of smart road furniture such as traffic lights to 60 new areas of the country, which send their status wirelessly to AVs so vehicles know when to stop and go. The country has yet to implement 5G networking of different frequencies on a large scale.

The country has been exceeding European Union limits on nitrogen pollution, which led the government to lower speed limits in March 2020.[31] Measures that push people to change their vehicles, whether for road tolling or to move to electric power to reduce pollution and carbon emissions, could also increase adoption of AVs.

EV charging stations top five



Source: International Energy Agency, *Global EV outlook* (2019). Scaled by population.

> "The time that is needed to solve the 'edge-cases' to make it work in real life, will probably hold-off the introduction of self-driving solutions on our public roads any time soon."

Stijn de Groen
Lead for Mobility 2030
KPMG in the Netherlands

3 | Norway

10	5	3	5
Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance

Norway has retained its third place position in the AVRI, with its openness to new transport technology demonstrated by its world-leading adoption of EVs, a precursor for electric-powered AVs. A majority of passenger vehicles bought in 2019, 56 percent, were battery or plug-in hybrids, far ahead of the Netherlands on 15 percent, as a result of high taxes on internal combustion vehicles and fuels and subsidies for EVs that can make the after-tax cost of a new electric car significantly cheaper than its fossil fuel equivalent.[32]

Norway is a close second to the Netherlands on EV charging stations, with 2.4 per thousand people, has excellent broadband and 4G coverage and is rated second only to Finland on the availability of latest technologies.

The country extended its use of AVs in 2019, in some cases moving them from testing to real applications. Three bus routes in Oslo are now driverless, running on ordinary if relatively quiet roads, as well a service in Kongsberg from the railway station to the city's technology center. Through a risk analysis, the industry concluded that the top speed for AVs on roads can be increased from 16 to 20kph (10 to 12mph) and is considering a further increase to 25kph (16mph), similar to much urban traffic. The government has also legislated to give everyone equal access to AVs, rather than setting age or other limits.

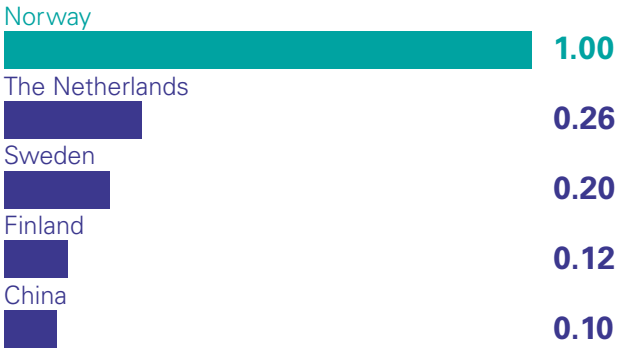
Ståle Hagen, Head of Mobility and Transport, KPMG in Norway, says that driverless bus services are becoming familiar to Norwegians. "They are not skeptical about using autonomous buses. They think it's normal and ordinary," he says.

The country is testing such vehicles in extreme weather, with pilots of AV trucks, cars and buses on the snow-bound Svalbard islands in the Arctic Circle. Oslo airport is using AVs to clear snow and ice and there have been pilots of using autonomous trucks to link mines and railway depots in northern Norway.

Norway is also introducing other kinds of autonomous equipment. It has a leading position in autonomous boats, with several short ferry routes across fjords now operated in a largely automated fashion although with human back-up. Similar boats are also being introduced to move freight in Norway's coastal waters.[33] On construction work, many municipalities are mandating or requesting the use of electrically-powered autonomous equipment.

Hagen says that Norway already has excellent mapping, but needs to develop real-time data on roads covering the likes of traffic conditions and accidents. More generally, "we need common funding and a common national program for autonomous driving," he says. "Then we can have standardization, and take further steps towards autonomous cars in traffic."

Market share of electric cars top five



Source: EV-Volumes.com (2019)

> "Norwegians are not skeptical about using autonomous buses. They think it's normal and ordinary."
>
> **Ståle Hagen**
> Head of Mobility and Transport
> KPMG in Norway

4 | United States

6 Policy and legislation
2 Technology and innovation
9 Infrastructure
6 Consumer acceptance

The US is second only to Israel on the AVRI's technology and innovation pillar. It has 420 AV company headquarters, 44 percent of all of those tracked in this research, although ratings on this measure are scaled by population. It is among five countries receiving the highest rating for industry partnerships.

American technology-focused companies and established vehicle makers continue to dominate AV development worldwide. In June 2019 Apple bought Drive.ai, a Silicon Valley-based startup that has piloted AV technology that can be fitted to existing vehicles on fixed routes in Texas.[34] Then in March 2020 it raised US$2.25 billion from outside investors and its finance head suggested it could eventually become a standalone firm.[35] The same month saw ride-hailing giant Uber resuming testing of AVs in its home city San Francisco, two years after one of its vehicles was involved in a fatal accident in Arizona.[36]

US vehicle makers also continued to develop work on AVs. In January 2020, General Motors' Cruise division unveiled the Origin, a purpose-built self-driving car designed for ride-sharing. It has no controls and room for six passengers facing each other, with those at the front looking backwards.[37] Ford's 2017 investment of US$1 billion in American AV startup Argo AI, which has run tests on public roads in Florida, Michigan, California and Texas, has been followed in July 2019 by German vehicle maker Volkswagen announcing it will put in a further US$2.6 billion.[38]

However, Ford is among companies that have curbed ambitions over when AVs will be ready for widespread use. "We overestimated the arrival of autonomous vehicles," said Ford's chief executive officer Jim Hackett in April 2019, adding that the company's first AV was still planned for 2021 but "its applications will be narrow, what we call geo-fenced, because the problem is so complex".[39]

Other countries are working to update road infrastructure and use AVs in public transport, but the US performs relatively poorly on infrastructure and is more focused on private vehicles and taxis. Governmental work to introduce AVs is concentrated at the state and city level, with strong examples of the latter including Detroit and Pittsburgh (see Cities to watch section). While state and city work can be more agile and tailored to local circumstances, it can lead to less standardization.

Cloud computing, AI and IoT top five

Source: Huawei, *Global connectivity index* (2019)

5 | Finland

4 Policy and legislation
8 Technology and innovation
11 Infrastructure
2 Consumer acceptance

Finland's high rating in the AVRI is partly due to the strong performance of its government, which receives the highest score for both its AV regulations and also for the efficiency of the country's legal system in challenging regulations, as rated by business executives surveyed by the World Economic Forum. Finland's government has already done a lot of work to ready the country for AVs, including opening its entire road network for trials and passing a new Road Traffic Act which came into force in June 2020. "Legally, the building blocks were put in place quite some time ago," says Henk-Jan Kruit, Global Strategy Group Manager, KPMG in Finland. The country is lobbying for changes in European Union legislation, such as where mentions of 'drivers' could block use of driverless vehicles.

Local authorities and national government are pushing AVs as part of moves to reduce environmental impacts and private car use, leading to Finland's focus on driverless minibuses, first trialed by the Helsinki region's transport authority HSL in the suburb of Kivistö in 2015.[40] Much of this work is focused on the capital Helsinki (profiled in Cities to watch).

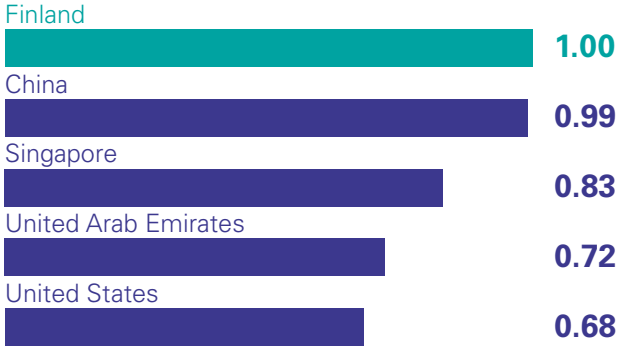
In April 2019, the City of Espoo — which along with Helsinki is part of the Finnish Capital Region — began public operation of the all-weather Gacha driverless bus.[41] In September, a service opened that includes the campus of Finnish telecoms equipment maker Nokia in Kera, and uses its 5G network. Kruit says Espoo has planned to have driverless shuttle buses in permanent commercial service by 2021, prior to the local elections that year.[42]

Along with Japanese retailer Muji, the Gacha bus is co-designed by Espoo-based AV technology company Sensible 4, which in February 2020 raised US$7 million to fund expansion elsewhere in Europe and in Asia.[43] Kruit says that Finland has a strong public-private ecosystem working on AVs, supported by the annual startup and tech event called 'Slush'. This ecosystem includes established companies and startups, public sector organizations and direct government driven organizations — examples of active stakeholders include Roadcloud, VTT, Maanmittauslaitos, Vaisala, TMFG, Traficom, LVM Väylä, Business Finland and Forum Virium Helsinki.

Finland benefits from good use of technology including 5G as well as a significant talent pool. The country espouses a breadth of talented engineers, many of whom have notable experience being part of Nokia's legacy, a Finnish multinational telecommunications and technology company. Finnish ease with using technology is reflected by the country leading the world on the AVRI's measures of digital skills and use of ride-hailing. Finland also has a public-private ecosystem of all sorts of companies working together on AV implementation.[44]

Kruit says that Finland is a small market and lacks a major vehicle maker which could be a core driver behind AV development. However, this does allow smaller companies greater freedom to develop independently. He says the government could consider further improving strategy deployment across both legislation and AV related subsidies. "But I would say it is doing a great job already," he adds.

Online ride-hailing market penetration top five



Source: Statista (2020)

> "Legally, the building blocks for AVs in Finland were put in place quite some time ago."
>
> **Henk-Jan Kruit**
> Global Strategy Group Manager
> KPMG in Finland

6 | Sweden

15 Policy and legislation
6 Technology and innovation
8 Infrastructure
3 Consumer acceptance

Sweden, which is overtaken by its neighbor Finland to take sixth place in the AVRI, has broadened the scope of its AV tests on public roads, increased the maximum speed of such vehicles to 80kph (50 mph) and allowed human supervisors to leave their hands off steering wheels. Swedish companies including truck maker Scania, Volvo Cars and Volvo Trucks are all continuing with trials.

The country's AV work has a focus on logistics. In May 2019, an Einride pod — a driverless electric truck without a cab, built by Swedish AV startup Einride — drove on a public road at German logistics group DB Schenker's facility in Jönköping in southern Sweden between a warehouse and a terminal.[45] The following month, an Einride pod delivered goods to a temporary branch of German supermarket Lidl in Stockholm, its first journey in an urban environment, using an advanced mobile network provided by Swedish telecoms company Ericsson.[46]

Christoffer Sellberg, Head of Automotive, KPMG in Sweden, says that he expects the advent of 5G mobile networking to be a catalyst for greater adoption of AVs. But he adds that the country's government should consider going faster on developing regulations and public transport trials. "We see changes in the regulatory tone, but I don't think it is fast enough," he says, with one government agency not planning to start testing driverless buses until 2022.

Sweden tops the people and civil society technology use sub-indicator of KPMG's 2019 Change Readiness Index and has among the highest scores for ICT adoption and digital skills, all contributing to its third place in the consumer acceptance pillar. It also performs well on some measures in the technology pillar, including availability of the latest technologies and innovation capability. "We are early adopters of technology, and that's a strength. We're curious," says Sellberg, adding that this should help in developing how AVs interact with humans and society, something which he believes will be a critical factor for improved AV maturity in the market.

However, he thinks that the country would benefit from greater interaction between organizations working on AVs. "I would love to see the ecosystem come together — the technology providers, the OEMs [original equipment makers of vehicles] and the authorities. The power of the ecosystem is important," he says.

Civil society technology use top five

Source: KPMG International, *Change readiness index* (2019)

> "We are early adopters of technology, and that's a strength. We're curious."
>
> **Christoffer Sellberg**
> Head of Automotive
> KPMG in Sweden

7 | South Korea

16 Policy and legislation
7 Technology and innovation
2 Infrastructure
10 Consumer acceptance

South Korea climbs six places in this edition of the AVRI, the biggest rise of any country. It has advanced on a number of measures in the infrastructure pillar, where it moved from fourth to second place, supported by fast broadband and mobile connection speeds added in this edition, as well as the highest rating for 4G network coverage. It moved up nine places on consumer acceptance as a result of a rise in testing locations, an increase in use of ride-hailing services and improved assessments of both civil society technology use and consumer adoption of technology, with the country now leading on the latter measure.

Its ambition is reflected in the country's national strategy for developing AVs as part of its Future Car Industry National Vision, which also promotes electric and hydrogen vehicles, published in October 2019. It was launched by President Moon Jae-in, who said: "Our goal is to become the leading country for future cars by 2030." This will involve Korean companies investing KRW 60 trillion (US$49 billion) with KRW 2.2 trillion from government over the last decade.[47] The country hopes for benefits including road deaths reduced by three-quarters by 2030, as well as becoming a leader in AV technology.[48]

As part of the strategy's plans for AVs, by 2024 the government plans to introduce supporting infrastructure on major roads including all 5,500km (3,400 miles) of express toll-roads; wireless communication between cars and roadside systems on major roads; detailed three-dimensional mapping; an integrated traffic control system including signage; completion of legislative process; and strengthened security. By 2024 the country also intends to have legislation and institutions in place, and by 2030, the aim is for all 110,000km of roads in the country to be covered by the mapping work. By 2025, the strategy projects that 9 percent of new cars sold will be AVs working at either level 3 or 4, rising to 54 percent by 2030 with 12 percent working at level 4.

Hyo-Jin Kim, Partner, Head of Infrastructure, KPMG in Korea, says the plan has been developed with input from across government and industry. "2019's Future Car Industry National Vision suggests specific timelines for legislative process, investment, and infrastructure, and this would enable us to tackle key challenges including safety, environment, and technology. "It gives us more certainty about national future direction," he says.

Linked to the strategy, the government has established a Future Car Industry Alliance to help vehicle and component makers work with technology companies and others. Korean vehicle-maker Hyundai is already heavily involved in AVs, having announced plans for an innovation center in Singapore, collaboration with Russian technology company Yandex and, in September 2019, a US$1.6 billion investment in a joint-venture with Irish AV technology specialist Aptiv.[49]

But while the country's large vehicle companies are well-placed, Kim adds that the government's financial support for small companies manufacturing AV parts will soon be available as the government's plan is to increase the domestic supply ratio from 50 percent to 80 percent within the country. The country is also behind others on developing use of AI, he adds, and consumers may take some convincing to pioneer use of AVs as a new technology. However, the country has compensating strengths, with its excellent 4G mobile network coverage being supplemented by 5G services launched in 2019.

4G coverage top five

Source: OpenSignal (2019)

> "2019's Future Car Industry National Vision gives us more certainty about national future direction."
>
> **Hyo-Jin Kim**
> Partner, Head of Infrastructure
> KPMG in Korea

8 | United Arab Emirates

8 Policy and legislation
22 Technology and innovation
4 Infrastructure
4 Consumer acceptance

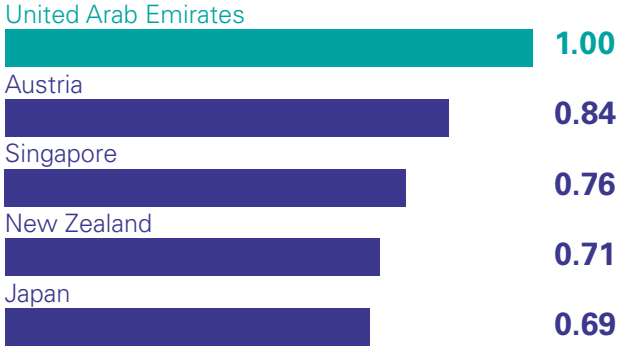
Ravi Suri, Partner, Global Head of Infrastructure Finance, KPMG in the Lower Gulf, says that the UAE's focus on developing smart technologies will play a significant role in the adoption of AVs. The country is continuing with its strategy of making 25 percent of transport autonomous by 2030, a move initiated in 2016. The country has appointed a minister with specific responsibility for AI, with an associated national program that ran a conference on the topic in April 2019 and established an internship program for 500 students earlier that year.[50]

The UAE, which moves up one place overall and gains fourth place on both the infrastructure and consumer acceptance pillars, performs even more strongly on several individual measures. It leads on technology infrastructure change readiness, mobile data speeds and the readiness of individuals. It is second-placed on government readiness for change and future orientation, as well as consumer ICT adoption, and third on the efficiency of its legal system in challenging regulations, according to executives surveyed by the World Economic Forum.

"The UAE continues to remain steadfast in its resolve to move towards autonomous vehicles," says Suri. "Given its strong interest in AI, blockchain, 5G and maintaining good-quality roads, they are on the way to doing it."

The graph here depicts the scores of the countries scoring highest in change readiness for technology infrastructure, with the UAE leading the way.

Technology infrastructure change readiness top five



Source: KPMG International, *Change readiness index* (2019)

> "The UAE continues to remain steadfast in its resolve to move towards autonomous vehicles."
>
> **Ravi Suri**
> Partner, Global Head of Infrastructure Finance
> KPMG in the Lower Gulf

9 | United Kingdom

2 Policy and legislation
9 Technology and innovation
16 Infrastructure
12 Consumer acceptance

Although it drops two places overall, the UK retains its second place on the Policy and Legislation pillar, with the government continuing to make substantial progress in this area over the past year. Building on 2018's Automated and Electric Vehicles Act, UK Government launched its second consultation paper in a three-year review of the UK's regulatory framework for automated vehicles. This explores AV regulation for public service vehicles, including how unstaffed minibuses or taxis would be kept safe and clean for passengers. Furthermore, in support of its Future of Transport Regulatory Review, UK Government has recently launched a wide-ranging consultation considering (amongst other areas) flexible bus services, micromobility vehicles such as electric scooters and mobility as a service (MaaS).[51] KPMG's Director for Future Mobility in the UK, Ben Foulser, notes that "the UK is undertaking a pervasive and comprehensive review, not just of discrete pieces of the picture but the breadth of the mobility ecosystem."

UK Government and industry have invested close to £200 million (US$250 million) establishing six test facilities for AVs in south-east and central England, coordinated collectively as "TestBed UK" by Zenzic (formerly known as Meridian). In September 2019 Zenzic published a well-received report which identified more than 500 milestones that would be required to get connected AVs onto the UK's roads in significant numbers by 2030, and "golden threads" of activities.[52] Among its key points were that societal outcomes must be central to AV planning, that safety is vital for public acceptance and that cybersecurity is a major UK competitive advantage. On the last point, Zenzic awarded £1.2 million (US$1.5 million) to seven cybersecurity-related projects and published a report summarizing their findings, following a competition launched in August 2019.[53] The UK's strength in this area is recognized in this AVRI by the country leading a new measure on cybersecurity compiled by the World Economic Forum.

Foulser reflects that the UK's technology companies, universities, and research institutions are making a significant contribution to its AV capabilities. In December 2019, Alphabet's AV company Waymo bought Latent Logic, a machine learning company spun out of Oxford University's Department of Computer Science.[54] Scotland has particular strengths in photonics, light-based technology that can be used in vehicle sensors. There are a number of UK-based trials, including upcoming public service tests of a full-length 11.5 meter AV bus by transport operator Stagecoach, vehicle maker Alexander Dennis and technology company Fusion Processing.[55]

"The UK has a really healthy ecosystem for early stage work, with a lot of tests and trials," says Sarah Owen-Vandersluis, Partner, Head of Future Mobility, KPMG in the UK. But she adds that there are challenges in scaling up such work, as well as the quality of telecoms infrastructure and encouraging collaboration between organizations.

Cybersecurity top five

International Telecoms Union, *Global cybersecurity index* (2018)

> "The UK has a really healthy ecosystem for early stage work, with a lot of tests and trials."
>
> **Sarah Owen-Vandersluis**
> Partner, Head of Future Mobility
> KPMG in the UK

10 | Denmark

12 Policy and legislation
15 Technology and innovation
10 Infrastructure
8 Consumer acceptance

Denmark is the highest-ranked of the five countries and jurisdictions joining this edition of the AVRI. It is one of the most digitally-enabled countries in the world, with most public services available for online self-service and consumers keen to adopt new technology and transport options. It has good roads, is investing in electric charging stations and the government is willing to co-fund projects.

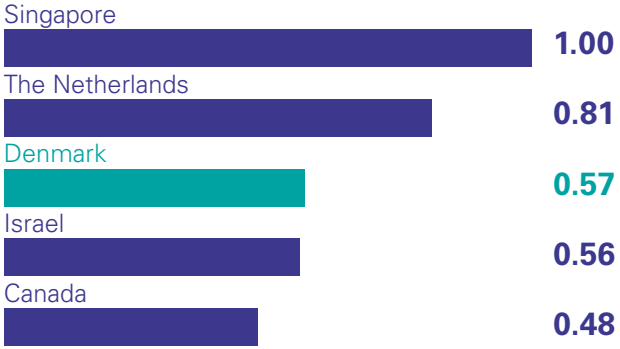
The country is also third highest on the percentage of the population living near test sites, with Denmark allowing AV tests on public roads anywhere in the country as a result of changes to the Road Traffic Act in May 2017. However, the application procedure can be lengthy, typically taking a year from application to operations starting. Applications require the approval of a third-party safety assessor, whose role is not clearly defined, before they are filed — something not required in Sweden or Norway.

Despite the cumbersome application process, March 2020 saw the opening of SmartBus, Denmark's first driverless bus service, running on a 2.1km (1.3 mile) route in Aalborg. The free-to-use service operates two 11-passenger vehicles, although following its opening it has been running empty due to coronavirus regulations.[56] Another service, a loop around the newly-built Copenhagen district of Nordhavn connecting the railway station, car parking and local facilities, gained approval in March 2020 and could open in summer 2020.[57]

Both projects are run by AV specialist Holo, which has also operated or is operating similar pilots in Estonia, Finland, Norway and Sweden. It is one of the very few Danish companies working in the field and there is no domestic car production. Morten Reimer, Transport and Mobility Advisor at KPMG in Denmark, says the lack of multiple AV players at the Danish market is a weakness, although it does encourage collaboration between businesses and government, something the country is experienced in doing. Another issue is high levels of taxation on vehicle assistance systems, he adds.

Reimer says the country could take better advantage of its strengths with a national AV strategy and roadmap that supports a new approach to infrastructure planning and design. That could include future planning of AV use, guidelines on AV infrastructure and technical requirements, new way of financing AV projects and establishment of independent user groups. "We have pilot testing at the moment, but we need this at a bigger scale over larger areas," he adds. "Larger-scale AV projects will have an impact and will produce more of the essential data needed to make the right future planning and decisions, e.g. data about user needs and data on how the mobility ecosystem changes, when AV is introduced."

Population living near test areas top five



Source: Bloomberg Philanthropies and Aspen Institute (2020)

> "We have pilot testing at the moment, but we need this at a bigger scale over larger areas."
>
> **Morten Reimer**
> Transport and Mobility Advisor
> KPMG in Denmark

11 | Japan

18	3	6	18
Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance

Japan has risen from fifth to third on the technology and innovation pillar of the AVRI, and has the highest number of AV-related patents of any of the countries in the research, both in absolute numbers and when scaled by population, the latter being the measure used in the index. It performs less well on policy and legislation, but is addressing this with two pieces of legislation enacted in May 2019. The revised Road Transport Vehicle Act, in force from April 2020, includes legal recognition of such vehicles, an inspection regime and a permit system.[58] The revised Road Traffic Act defines Automated Driving Devices and allows those using AVs to operate mobile phones or car navigation systems, although it also requires them to be able to take over manual operation immediately if a problem occurs.

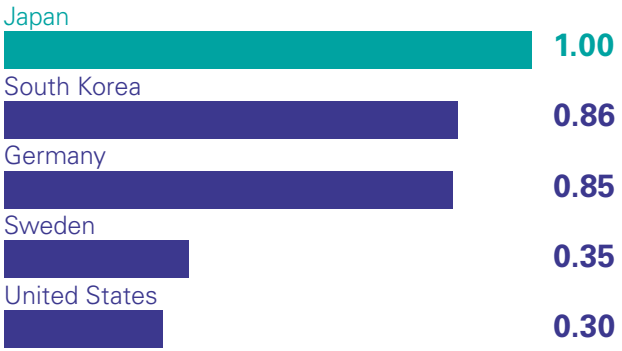
In September 2019, Tokyo's Metropolitan Police Department issued new rules for AV testing, including limiting vehicles to 20kph (12mph), meeting cybersecurity standards and installing recording devices in case of traffic accidents. But Japan should do more on accidents involving AVs, including stating how these should be investigated and analyzed and deciding who bears liability, according to Megumu Komikado, Partner, Head of KPMG Mobility Research Japan and Head of Automotive, KPMG in Japan.

Komikado adds that the country has a number of advantages in introducing AVs, including good standards of driving etiquette and road maintenance — it is ranked third of the countries in the AVRI for its road quality by the World Economic Forum. It also has a strong vehicle manufacturing sector, with Honda expecting to launch a model that supports Level 3 autonomous driving in 2020, and technology companies specializing in relevant areas including lidar, image recognition and dynamic mapping.

But while the country has good 4G mobile coverage, introduction of 5G has been delayed with countries including South Korea further ahead. Other challenges include the fact that Japan's road network includes a large number of tunnels, multi-level highways and very narrow urban streets which will be hard for AVs to navigate. The country also suffers from a shortage of engineers specializing in IoT technologies and, in particular, AI.

Komikado says Japan could improve its readiness with further legal and regulatory changes and measures to support increases in engineering capacity. He also advocates a special zone for testing AVs at Level 4 and above, created by the public and private sectors. "We expect that by 2025, maybe before, the conditions for Level 4 will be met, at least for special zones and areas," he says.

AV-related patents top five



Source: PatSeer (2019). Scaled by population.

> "We expect that by 2025, maybe before, the conditions for Level 4 will be met."
>
> **Megumu Komikado**
> Partner, Head of KPMG Mobility Research Japan and Head of Automotive
> KPMG in Japan

12 | Canada

9 Policy and legislation
13 Technology and innovation
13 Infrastructure
13 Consumer acceptance

Canada is one of the countries assessed by this research as having the highest ratings for both government-funded AV pilots and industry partnerships, and much of its significant work is focused on collaboration. The country shares the Great Lakes vehicle manufacturing cluster with the US — Detroit faces the city of Windsor in Ontario — with the industry employing more than 125,000 people nationally and assembling more than two million vehicles a year.[59] Organizations collaborate through the Ontario's Autonomous Vehicle Innovation Network, which is supported by the province's government. In January 2020, it said it would be working with Canada's Automotive Parts Manufacturer's Association to develop Project Arrow, a concept vehicle that would use the country's expertise in AVs, connectivity, electric and alternative fuels.[60]

Work in Quebec is more focused on research and use of such vehicles in applications including forestry, but both provinces have given their transport ministers authority to approve AV tests.

Much work on AVs in Canada is embedded within larger foundational projects, an example being the Canadian Radio-television and Telecommunications Commission work in 2020 to review and revise legislation to enable connected vehicles (which includes AVs). Another was Infrastructure Canada's Smart Cities Challenge, for which the winners were announced in May 2019,[61] where a third of the applications specifically focused on connected and autonomous vehicles. The City of Montréal, which was awarded the top C$50 million (US$37 million) prize in the competition, includes use of AVs in its plans to improve public transport and access to food.[62]

Colin Earp, National Transport Leader and Global InfraTech Chair, KPMG in Canada, says the country benefits from a depth of technology knowledge. "Canada is the world-leading hub of AI," he says, referring to a key technology for AVs. "There is a talent capability in AI, decision telematics and lidar at a density found nowhere else in the world."

Other strengths include the size and sophistication of the country's vehicle parts manufacturing sector, a wide range of urban and rural conditions for testing, and a political willingness to innovate on transport legislation and policies. An example of the last is the Ontario town of Innisfil using ride-hailing company Uber as its subsidized public transport provider.[63]

The country's geographical size and devolved governmental structure means initiatives require significant stakeholder management and engagement, but this can mean they are better-planned. "All the conditions should be right for Canada to be forging ahead in this area," Earp says.

Industry partnerships

Top performing countries and jurisdictions

- Canada
- China
- Germany
- South Korea
- United States

Source: KPMG International (2020)

> "Canada is the world-leading hub of AI. There is a talent capability in AI, decision telematics and lidar at a density found nowhere else in the world."
>
> **Colin Earp**
> National Transport Leader and Global InfraTech Chair
> KPMG in Canada

13 | Taiwan

Taiwan, a new addition to the AVRI, is one of five countries and jurisdictions given the top rating for government-funded AV pilots. In December 2018, the Taiwanese Legislative Yuan (parliament) passed the Unmanned Vehicles Technology Innovative Experimentation Act.[64] This established a framework for testing road AVs, as well as drones, autonomous boats and other AVs, including regulations for licensing vehicles, informing the public and safety assessments.

The new law was followed by the opening of Taiwan CAR Lab (for autonomous vehicle road-test, connected V2V, and infrastructure design) in Tainan in February 2019 by President Tsai Ing-wen.[65] The compact, 1.75 hectare facility focuses on situations likely to arise on Taiwan's mixed-use, low-speed urban roads.[66] In 2018, its 23 million people had 13.8 million motorcycles on its roads, twice the number of cars.[67] "Our driving conditions are quite close to those in many Asia-Pacific developing countries, although with better regulations," says Richard Hsu, Manager, Advisory, KPMG in Taiwan. "Companies can come to Taiwan to test vehicles so they can adapt their driverless vehicle technology for those countries."

There are other trials taking advantage of the new law, including WinBus, an AV minibus that started in May 2020, running for a year around sightseeing routes from Changhua Coastal Industrial Park and involving state-owned telecoms provider CHT and mapping provider KingWayTek.[68]

More generally, local authorities in Taiwan are looking at how to use AV for public transportation, to help reduce traffic congestion and solve a shortage of night-time bus drivers. Driverless electric minibuses have been used since 2017, initially on the campus of National Taiwan University in Taipei.[69] In February 2020 the Taipei Smart City Project Management Office (PMO) and the city's transport department decided to start night-time, on-road trial services of autonomous buses that should be routinely operated at 00:30~2:30 AM, Mon~Fri). Taipei Smart City PMO and Taipei DOT choose Turing Drive, another Taiwanese AV bus R&D team, to collaborate from May on a stretch of road with dedicated bus lanes, with passengers joining the trial in September. Drivers will operate the vehicles on other sections of the route.[70]

Taiwan has local AV companies including 7StarLake, which ran the 2017 National Taiwan University tests and focused on introducing AV buses, and Turing Drive, which is involved in the Taipei night-time bus trials. It also benefits from its strong automotive part production sector, with Tesla among the vehicle makers that use its products and particular experience in lidar and sensor technologies. Hsu says this focus on parts may also help in converting existing vehicles to autonomous operation, a lower-cost option that may be attractive for developing countries.

Government-funded AV pilots

Top performing countries and jurisdictions

- Canada
- Czech Republic
- Singapore
- South Korea
- Taiwan

Source: KPMG International (2020)

> "Companies can come to Taiwan to test vehicles so they can adapt their technology for developing countries."
>
> **Richard Hsu**
> Manager, Advisory
> KPMG in Taiwan

14 | Germany

7 Policy and legislation
4 Technology and innovation
19 Infrastructure
21 Consumer acceptance

Germany retains the fourth place it held in the previous edition of the AVRI for technology and innovation, where it tops the innovation capability measure and is one of five countries getting the highest rating for industry partnerships. It is third on both AV-related patents and on investments in AV-related companies.

This strength is demonstrated by the innovation shown by German vehicle makers in their international work. In January 2019, Daimler Trucks unveiled its Freightliner Cascadia, the first truck in North America to include some automated assistance, at Las Vegas' Consumer Electronics Show. Daimler said it would spend EUR500 million (US$570 million) on AV trucking, with Daimler Trucks chief executive Martin Daum announcing a goal of "highly automated driving" within a decade.[71] In September 2019, the company started testing a fully autonomous Freightliner Cascadia on public roads in Virginia in the US, although with a safety driver present.[72] In February 2019, BMW and Daimler said they would collaborate on AV technology that will work on both highways and in urban areas, with Volkswagen's chief executive saying it might join this work.[73] BMW is involved in tests in China, and testing sites in the Czech Republic and Hungary both involve German manufacturers.

But Germany's relative performance has declined on the other pillars, meaning the country drops six places overall. In December 2019, the cross-sectoral National Platform Future of Mobility, convened by the Federal Government, published its recommendations regarding actions needed for the introduction of autonomous driving, in particular regarding licensing, data exchange, and legislation and consumer acceptance. The last year has seen public transport providers moving tests of autonomous buses from closed areas to public roads, including operators in Berlin, Hamburg and Leipzig and national railway company Deutsche Bahn. However, they have made different technology choices with Hamburg's bus operator working on communications infrastructure built into roads but Leipzig's preferring to place this technology on buses.

Such divergence is typical of Germany's development of AVs, according to Moritz Püstow, Partner, KPMG Law in Germany. "We have a lot of movement at the municipality level, but we still lack a Germany-wide strategy," he says. "The discussion is broad. We see cross-sectoral roundtables, there is a federal strategy for automated and connected driving from 2015, legislation allows for level 4 driving since 2017 and we see AV test-beds on federal highways and on a local level. However, success will depend on the 11,000 German municipalities and we see a lack of strategy and coordination on that level.

Püstow adds that people in Germany may be less keen on adopting AVs than elsewhere, partly due to a national skepticism over new technologies. "Driving cars is an expression of freedom as well, and this is maybe stronger than in other countries," he adds.

Innovation capability top five

Source: World Economic Forum, *Global competitiveness index* (2019)

> "Success will depend on the 11,000 German municipalities and we see a lack of strategy and coordination on that level."
>
> **Moritz Püstow**
> Partner
> KPMG Law in Germany

15 | Australia

17 Policy and legislation
17 Technology and innovation
12 Infrastructure
9 Consumer acceptance

Australia is one of just four countries receiving the highest score for its AV regulations. Its federal government was early in moving to reform driving laws to enable use of AVs, and this work is continuing through the National Transport Commission's Automated Vehicle Program.[74] "What we have seen in the last 12 to 18 months is a lot more AV related activity at the state level, particularly from the infrastructure perspective," says Praveen Thakur, Partner, Transport and Infrastructure, KPMG in Australia. Examples include Victoria's North East Link Road project, where the potential impact of AVs was considered within the business case,[75] and Queensland's plans for mobility as a service which consider automation as an emerging technology.[76]

Transport for NSW has been testing autonomous buses since 2017, originally at Sydney's Olympic Park, and in January 2019 it published a plan for their adoption over coming decades.[77] In July 2019, with transport operator Busways, vehicle maker EasyMile and Coffs Harbour City Council, the agency started offering an on-demand service called BusBot to residents of a retirement village, summoned using a smartphone app.[78]

In May and June 2019, motoring organization RAC began offering residents of Bussleton in Western Australia rides in its driverless electric Intellibus on public roads, as well as continuing an earlier trial in South Perth that started in 2016.[79]

Australian mining companies have used AVs within closed sites for a number of years, and Brazil and Chile have done likewise. Rio Tinto started using fully remote-controlled trucks at two iron ore pits in the Pilbara region of Western Australia in October 2015, with the vehicles largely controlled from Perth, 1,200km (750 miles) away.[80]

On infrastructure, Australia jointly leads a measure of broadband quality in the *2019 Global Connectivity Index* published by Chinese telecoms company Huawei, along with Singapore. The Australian government has been improving broadband services over the last few years under its National Broadband Network program, although the intention to connect most homes and businesses to fiber-optic cables was diluted to use a range of technologies.[81]

Thakur says that Australia has strengths in its regulatory environment, the way autonomy is being considered in infrastructure projects and policies, and a range of trials are being undertaken across the nation. However, he says that more could be done by companies and organizations involved in AVs to engage the public, in advance of the technology being widely available. "The industry tends to be quite passive in communicating and engaging with the community. It would be beneficial if it could take up more of a leadership role," he says.

AV regulations

Top performing countries and jurisdictions

- Australia
- Finland
- The Netherlands
- Singapore

Source: KPMG International (2020)

> "In the last 12 to 18 months we have seen a lot more AV related activity at the state level, particularly on infrastructure."
>
> **Praveen Thakur**
> Partner, Transport and Infrastructure
> KPMG in Australia

16 Israel

As in the previous edition of the AVRI, Israel leads the technology pillar due to its startup and corporate strength in this sector, with 84 AV-focused companies headquartered in the country. This is second only to the US by number, and is by far the highest when measured by head of population. The country also leads on investments in AV-related companies, again scaled by population, and is rated third on access to the latest technology. "Innovation is our major strength. We're the best in the world," says Zeev Rotem, Head of Strategy and Change for KPMG in Israel.

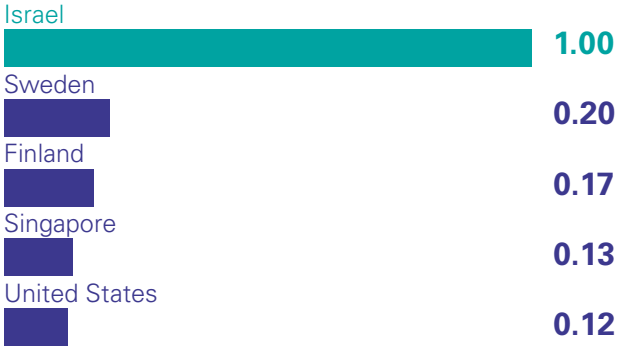
This strength was illustrated in May 2020 when US technology company Intel bought Moovit, an Israeli startup which provides an urban mobility app with more than 800 million users, for around US$900 million.[82] It did so to support its AV unit Mobileye, also based in Israel, which it bought in 2017.

"The acquisition of Moovit and all its data is a major support for Mobileye," says Rotem. Mobileye uses machine learning to develop its AV systems and Moovit collects large amounts of data from more than 7,500 transit agencies and operators who use its services. Rotem says that the Moovit purchase should help Mobileye in its aim of launching a robotaxi service in Tel Aviv by early 2022. The company has been active internationally, with trials starting in May 2019 with national mapping agency Ordnance Survey on creating a detailed roadside infrastructure dataset for Great Britain.[83]

Israel lags other countries on both policy and legislation and infrastructure, reflected by its low ratings in both pillars and it having the lowest score for 4G coverage. A specific problem comes from dated tax policies that provide incentives for car ownership, which result in very high levels of road congestion in Tel Aviv. Rotem says there is political interest in changing them, but the country has lacked effective government during 2019 and 2020 to be able to make such decisions.

However, some government agencies have been working to develop AV readiness with the help of the country's technology companies, with Israel Highways publishing a tender to create a digital database of road signs. Rotem also sees particular potential from companies offering mobility-as-a-service through fleets of AVs, such as to help major employers transport their staff to and from workplaces.

AV technology firm headquarters top five



Source: Topio Networks and Crunchbase Pro (2020) Scaled by population.

> "Innovation is our major strength. We're the best in the world."
>
> **Zeev Rotem**
> Head of Strategy and Change
> KPMG in Israel

17 New Zealand

5 Policy and legislation | 19 Technology and innovation | 20 Infrastructure | 14 Consumer acceptance

New Zealand rates well on policy and legislation, although it has dropped from third place to fifth in this pillar since the last edition of the AVRI. Over the last two years, the government has had a greater focus on the environment, the transformation of the transport system and greater use of public transport. "The government recognizes that technology plays an important role in this," says Istvan Csorogi, Director, Advisory, KPMG in New Zealand. This is supported by a push towards performance-based regulation that can provide a route from trials to on-road use of AVs.

Csorogi says that the country has an advantage on regulatory issues in that these are all managed nationally, rather than being split with states as in federal countries. "New Zealand's main strength is a supportive regulatory setting that provides an open permissive environment to test new technologies," he says.

However, the country does not invest large amounts in transport innovation. EVs have only a small market share of car ownership, with limited subsidies for adopting EVs. Local councils have recently started rolling out electric buses.

Csorogi adds that the government has been increasing its spending on transport infrastructure, but that New Zealand's low population density means that roads outside the main cities are lightly-used, making the wider deployment of roadside infrastructure for AVs uneconomical. Its geography contributes to its position of 24th among the AVRI countries and jurisdictions on road quality and 27th on 4G coverage.

On the commercial side, New Zealand transport technology company HMI Technologies has run AV trials in Christchurch, Melbourne and Sydney through its Ohmio division. In March 2019, it ran its first test of a 5G network connected vehicle on the streets of Auckland.[84]

New Zealand has disadvantages in developing AVs, including a lack of mainstream vehicle research, development and manufacturing and limited funding for innovation from private capital or government. Csorogi says it has the potential to succeed in specialist niches, such as autonomous aviation, including the use of drones for deliveries. It has been hosting tests of the Cora self-flying air taxi developed by Wisk, a US joint-venture of Boeing and Kitty Hawk.[85]

As the country's roads have inconsistent safety infrastructure and road markings, AVs could benefit from the use of more accurate satellite-based positioning. The New Zealand and Australian governments are continuing to work on joint trials of a Southern Positioning Augmentation Network that is due to become operational by 2023.[86]

Csorogi says that local innovation tends to take place in universities and is often then developed by foreign venture capital: "We need to pick our battles and focus on specialist applications," he says.

Quality of roads, places 21–25 of 30

Source: World Economic Forum, *Global competiveness report* (2019)

> "New Zealand's main strength is a good supportive regulatory setting, with an open permissive environment for testing new technologies."
>
> **Istvan Csorogi**
> Director, Advisory
> KPMG in New Zealand

18 | Austria

11 Policy and legislation
16 Technology and innovation
7 Infrastructure
24 Consumer acceptance

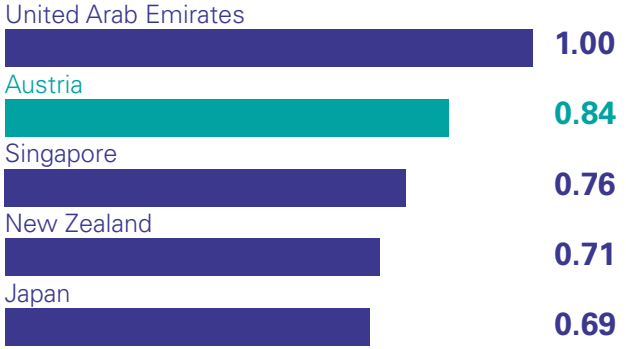
In March 2019, the Austrian government allowed people to take advantage of autonomous features in current-day cars, buses and trucks. Drivers can now take their hands off the steering wheel when staying within one lane on a main highway, although they need to retake control to change lanes, leave the road or if otherwise required. Users of cars and small trucks can also use self-parking systems outside the vehicle, as long as they are nearby and can stop the process.[87]

Werner Girth, Partner Advisory, KPMG in Austria welcomes the government's 2019 legal changes, but adds: "We're not on the forefront of legislation, but we are catching up. Given the importance of the sector for Austria I hope that we push the envelope further as we move forward."

This change to legislation allowed Vienna's public transport provider Wiener Linien to launch a trial of a self-driving minibus service with French AV startup Navya in June 2019. This was paused in July when one of the buses collided with a woman who received minor injuries.[88] The trial restarted a few days later after Wiener Linien found that the bus had reacted correctly by ringing a warning bell — which the woman did not hear as she had headphones on, as well as her eyes on a phone — then braking, with just 1.6 seconds between detection and the bus stopping. The transport authority said it did not see the need for technical adjustments, but appealed to locals to pay more attention to traffic.[89]

Last year also saw the Austrian government increasing its budget for seed and innovation funding. Girth says that still more funding is needed in this area. But he adds that Austria has a number of strengths in developing AVs, including a lot of small companies involved in researching the area and a wealth of scientific talent, particularly in Vienna and Graz, with the latter city acting as a hub for vehicle research. The country lies second in the technology infrastructure change readiness measure that is drawn from KPMG International's 2019 *Change Readiness Index*. Austria is also developing expertise in autonomous drones, with a flying taxi being demonstrated in April 2019 at a stadium in Vienna and former transport minister Norbert Hofer saying that such vehicles could be in use by 2025 and pledging legal changes to support this.[90]

Technology infrastructure change readiness top five



Source: KPMG International, *Change readiness index* (2019)

> "We're not on the forefront of legislation, but we are catching up. Given the importance of the sector for Austria I hope that we push the envelope further as we move forward."
>
> **Werner Girth**
> Partner, Advisory
> KPMG in Austria

19 | France

February 2019 heard President Emmanuel Macron reaffirming his intention for France to have AV-based transport services running by 2021 in a speech to the International Organization of Motor Vehicle Manufacturers. In May and November 2019, the French parliament passed two laws to help make this happen. The first moves liability for accidents involving experimental AVs from the person behind the steering wheel to the organization authorized to run the experiment. The second allows the government to modify other legislation to facilitate services using AVs, an example being an exemption for autonomous truck platoons from the rule that vehicles need to be at least 50 meters apart.

"We now have a quite comprehensive legislative framework," says Laurent des Places, Partner, Head of Automotive, KPMG in France. "Government officials in charge of this believe France is the most advanced country now, along with Japan." The government has also developed validation methods for AV systems, similar to those used to regulate aircraft. It is also sponsoring research, with April 2019 seeing the government announcing funding of EUR42 million (US$48 million) for 16 AV-related projects.[91]

In the private sector, June 2019 saw French vehicle maker Renault, with its Japanese partner Nissan, agree an exclusive alliance with US technology group Alphabet's AV unit Waymo which involves setting up joint-venture companies in France and Japan.[92] In October, Waymo and Renault said they were considering an autonomous transport system linking Paris' Charles de Gaulle airport and La Défense, an office complex west of the capital's center. The Île-de-France region's government is contributing EUR100 million (US$110 million) to this work, which could use the 2024 Olympic and Paralympic games in Paris as a showcase.[93]

"France now has a legal framework for autonomous vehicles that is unique in Europe." "The country has a long-standing policy stimulating collaboration projects between national or local government and private actors," says Laurent des Places. "This is really key to the development of autonomous vehicles and autonomous systems."

Other significant developments include French vehicle maker Peugeot working with Vinci Autoroutes on technology connecting vehicles to infrastructure, which can help AVs to use toll gates and navigate roadworks, and the July 2019 opening of an AV test-site at Montlhéry, a historic motor-racing circuit south of Paris.[94]

Des Places says that France has significant strengths, including a comprehensive national policy including legislation; effective co-operation within its 'AV Team France' of automotive, transport and technology companies, public research institutes and public authorities; a strong automotive sector; and a favorable environment for start-ups. But he adds that France lacks its own large technology companies, underlining the importance of partnerships such as that between Renault and Waymo.

Cybersecurity top five

Source: International Telecoms Union, *Global cybersecurity index* (2018)

> "France now has a legal framework for autonomous vehicles that is unique in Europe."
>
> **Laurent des Places**
> Partner, Head of Automotive
> KPMG in France

20 | China

In 2019, the Chinese government made it easier to test AVs on public roads, allowing this to take place in more cities and with fewer controls. Although human supervisors are still required in test vehicles, they do not need to touch the controls, and the number of test vehicles covered by a single license has risen from one to five as long as they are identical. In September, Shanghai became the first city to issue such permits, initially covering Chinese vehicle-maker SAIC and ride-hailing company Didi Chuxing, as well as BMW of Germany.[95] In March 2020, AV startup AutoX said it will launch 100 robotaxis in the city, the first allowed to operate at the speed limit of 80kph.[96] Beijing has also undertaken significant work on testing, profiled in the Cities to watch section.

The national transport department published a digital transport strategic plan and in September 2019 central government published a digital transport construction strategy, which covers AVs as well as changing energy sources and improving environmental performance of vehicles. From May 2019, the government has published new standards for AVs, including in March 2020 a version of the internationally-used autonomy levels zero to five. "China is evolving quite fast on national level policies and new standards," says Philip Ng, Partner and Head of Technology for KPMG in China. "It's a very high priority."

China is one of the countries assessed as leading on industry partnerships. The main commercial interest in use of AVs is in special-purpose trucks such as inside warehouses and mines and goods deliveries, with involvement by Chinese retailers including JD.com and Alibaba and use on city-to-city highways. Chinese companies are also building capacity as suppliers in AV technologies including chipsets, with around 36 investments made in 2019, and lidar, with four or five significant local companies. Ng says that suppliers are also developing sensors, AI algorithms and vehicle communications technologies.

He adds that the country's early introduction of 5G networking is significant: "China is leading the world, both on technology and pace of adoption and implementation," he says. Along with work to develop digital road infrastructure, this will build strong foundations for the introduction of AVs. Ng adds that the Chinese public appear receptive to using such vehicles, particularly younger people.

However, some challenges remain, including the need for highly precise digital maps — the development of which may be hindered by China having the lowest rating in the research for data sharing — and further development of policies and standards. A specific issue involves the heavy use of many Chinese roads by pedestrians and cyclists as well as motorized vehicles: "It is more complicated and presents additional challenges for autonomous driving," Ng says. To tackle this, he expects that four-lane highways will have one lane designated and equipped for AVs.

Industry partnerships

Top performing countries and jurisdictions

- Canada
- China
- Germany
- South Korea
- United States

Source: KPMG International (2020)

> "China is evolving quite fast on national level policies and new standards. It's a very high priority."

Philip Ng
Partner and Head of Technology
KPMG in China

21 | Belgium

20	18	18	23
Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance

Belgium, a new entrant to this edition of the AVRI, saw one of its first demonstration trips of a self-driving shuttle bus in May 2019 at Brussels airport. The vehicle is built by Dutch AV maker 2getthere and operated by the Flemish regional transport authority De Lijn. The airport and transport authority hope to open an autonomous, high-frequency shuttle service between the airport terminal, cargo business area and parking lots in 2021, running on a route that will be partly used by other traffic, using magnets in the ground as beacons.[97]

However, the country performs relatively poorly overall, particularly when compared with its neighbor the Netherlands, which is second-placed overall in the AVRI. This includes specific physical problems in introducing AVs. Among the 30 countries and jurisdictions in the AVRI, Belgium is fifth from bottom on road quality, based on the World Economic Forum's 2019 research, although these 30 do include the world's leading economies. But unlike the Netherlands, which often segregates different transport types, Belgian roads are often shared by cars, buses, cyclists, trams and pedestrians. "The way the roads are used doesn't make it easy to have sufficient safety guarantees for AVs," says Ivan Costermans, Executive Director, KPMG Advisory in Belgium. Their challenging nature could make the country a good location for comprehensive testing of AVs, however.

Belgium could particularly benefit from reduced congestion, if AVs help reduce traffic through improved public transport or more ride-sharing. But a further issue is that transport is largely the responsibility of Belgium's three powerful regional governments — the Dutch-speaking Flanders region (which runs De Lijn), French-speaking Wallonia and the capital region of Brussels — but with some transport as well as fuel taxes controlled by the federal government. "You have a very difficult political playing field where ultimately if you need to make things happen you need to have different levels of government working together," says Costermans. Although it's fair to say that legislative initiatives have already been taken mainly to facilitate testing of unmanned AVs.

Quality of roads bottom five

Source: World Economic Forum, *Global competiveness report* (2019)

> "The way the roads are used doesn't make it easy to have sufficient safety guarantees for AVs."
>
> **Ivan Costermans**
> Executive Director
> KPMG Advisory in Belgium

22 | Spain

23	23	15	17
Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance

Spain is hosting a number of AV trials, including the first phase of the Autonomous Ready Spain innovation program that involves the Spanish Directorate General of Traffic (DGT), Barcelona City Council, Spanish transport infrastructure company Ferrovial and Intel-owned AV technology provider Mobileye. Launched in December 2019, the program is focused on reducing accidents through driving assistance technologies, with 400 vehicles having been equipped with Mobileye's technology.[98]

Some locations are testing AV buses for tourist use. In January 2020, Spanish bus operator Avanza announced AutoMost, a pilot service connecting Malaga's cruise terminal with the city center on normal roads. It uses a 12 meter electric bus, is capable of carrying 60 passengers, developed with the support of Malaga City Council and a range of partners over the last three years.[99] Meanwhile, Lanzarote Council and the Canary Islands Development Fund are working on Cities Timanfaya, an autonomous electric minibus that will provide tourists with a multimedia tour of the Route of the Volcanoes in Timanfaya National Park, helping to control visitor flows in an environmentally sensitive area.[100]

In January 2020, the Universidad Autónoma de Madrid announced the introduction of a regular driverless bus service to its Cantoblanco campus over a 3.8km (2.4 miles) mixed traffic route, in collaboration with the DGT and the Consorcio de Transportes de la Comunidad de Madrid (the city's transport consortium), the first such service at a Spanish university.[101]

At the start of 2020, the government also announced work on a wide-ranging mobility law that will cover AVs.[102] However, developments have been delayed as the country deals with the coronavirus crisis. Spain is currently rated on the third level of a 15 point scale for the quality of its AV regulations, along with seven other countries.

The new law will also promote EVs, such as by providing more sites for recharging: "In comparison with some other European countries, Spain needs to improve its number of charging points," says Ovidio Turrado, Head of Infrastructure, KPMG in Spain. He adds that electricity providers have announced plans to increase provision, and there also is progress on 5G connectivity with networks now live in some cities. However, Turrado believes the country needs to go further.

"Spain needs to increase the number of initiatives on testing and promoting AVs at a wider level. It also needs to develop this mobility law so there is a national framework that helps to develop things at the country level," he says, with responsibility for transport split between the national government and Spain's powerful regions.

AV regulations

Top performing countries and jurisdictions

Highest scores	Second-highest scores	Third-highest scores
Australia	Belguim	Austria
Finland	New Zealand	Czech Republic
The Netherlands	Norway	Italy
Singapore	UK	South Korea
		Spain
		Taiwan
		UAE
		US

Source: KPMG International (2020)

> "Spain needs to increase the number of initiatives on testing and promoting AVs at a wider level."

Ovidio Turrado
Head of Infrastructure
KPMG in Spain

23 | Czech Republic

22 Policy and legislation
25 Technology and innovation
24 Infrastructure
22 Consumer acceptance

The Czech Republic is one of the five countries receiving the top rating for government-funded AV pilots, and testing is the country's main area of strength. 2020 should see construction start on German vehicle maker BMW's EUR300 million (US$340 million) AV test site at Sokolov, around 300km (190 miles) from the company's main development site in Munich. BMW plans to open the site, which will have around 100km of road allowing tests of city, highway and rural roads, in the second half of 2022. It will create around 700 jobs and has established a cooperation agreement with the University of West Bohemia.[103]

The country has several other test facilities under development. Czech investment group Accolade is planning to build on a site near Stříbro, which is similarly near the German border, to be used by companies developing AV technologies. It plans to open in 2022 at a cost of EUR180 million (US$200 million), which will also offer a range of road environments including European cities that do not use right-angled grids of roads.[104] Czech-based vehicle maker Skoda, part of Germany's Volkswagen, is working on a site while German safety company TÜV and French vehicle part maker Valeo Group are both looking to convert disused airfields.

"Our strength is that the automotive industry is already here," says Pavel Kliment, Partner, KPMG in the Czech Republic, with the country making vehicles for a number of companies. "That's why there is the focus on test sites." There is less research and development work, although there are good examples, such as German vehicle maker Porsche, another Volkswagen unit, and Italian parts maker Marelli have research partnerships with the Czech Technical University in Prague.[105]

Aside from testing, Kliment says that the Czech Republic lacks a legal framework for the use of AVs. The technology attracts attention when there is a significant announcement, such as when BMW detailed its test site plans in January 2020. "There are a lot of positive things happening, but it's not a strategic issue," he says. "I expect the importance will gradually grow over time, particularly when the test sites are completed."

Government-funded AV pilots

Top performing countries and jurisdictions

- Canada
- Czech Republic
- Singapore
- South Korea
- Taiwan

Source: KPMG International (2020)

> "Our strength is that the automotive industry is already here. That's why there is the focus on test sites."

Pavel Kliment
Partner
KPMG in the Czech Republic

24 | Italy

27 Policy and legislation
21 Technology and innovation
23 Infrastructure
26 Consumer acceptance

Italy, a new entrant to this edition of the AVRI, does well on AV-focused measures, reflecting the transport ministry's work in this area such as February 2018's Smart Roads decree, authorizing AV testing as long as vehicles have controls and an operator able to take control if required. It also created an Observatory for Smart Roads to monitor all experiments in Italy and examine those in other countries to develop best practice.

The country is also developing digital connectivity to support AVs, focusing on V2X (vehicle to everything) connections where vehicles communicate with other vehicles and infrastructure. Anas, the state-owned company that manages Italy's major roads, plans to spend EUR140 million (US$160 million) on connected vehicle technology for around 2,500km (1,550 miles) of its network, with specific work on roads including Rome's Grande Raccordo Anulare orbital motorway. This is despite Italy's government gaining the lowest score for its future orientation from the World Economic Forum, a measure which assesses policy stability, responsiveness to change, adaptability of legal framework to change and the government's long-term vision.

Following the Smart Roads decree, Italy's first and so far only tests started in 2019 in Parma and Turin. Both are run by VisLab, an autonomous driving company spun off from the University of Parma in 2009 and acquired by US semiconductor company Ambarella in 2015.[106] In February 2020, Parma City Council allowed the trials to take place throughout its area.

Turin is also hosting a trial of an AV minibus service run by US company Local Motors using Olli, an EV made entirely from 3D printed parts. In Padua, Italian company Next is testing modular AV minibuses which can dock or split up and take different routes depending on the destinations requested by passengers.

Ivan Cavalli, Manager, Transportation Sector, KPMG in Italy, says that the country benefits from all these, but that there are problems to solve including the high cost of AV technologies for consumers and local public transport providers, with the latter having a record of low investment in their vehicle fleets. The country also lacks national high-definition mapping, and there are questions over liability in the case of accidents involving AVs; the national trade association has published work on this, but so far no products are on offer. Many drivers already use 'black box' monitors in their cars for insurance, which could be used for AV policies.

As well as tackling these issues, Cavalli says Italy needs to promote collaboration between organizations working on AVs, such as to stimulate research by pooling expertise in Italian universities and to establish effective V2X communication. "It's important that providers work together to define common technology that enables all vehicles to communicate with all the other objects they could meet on the road," he says.

AV regulations

Top performing countries and jurisdictions

Highest scores	Second-highest scores	Third-highest scores
Australia	Belguim	Austria
Finland	New Zealand	Czech Republic
The Netherlands	Norway	Italy
Singapore	UK	South Korea
		Spain
		Taiwan
		UAE
		US

Source: KPMG International (2020)

> "It's important that providers work together to define common technology that enables all vehicles to communicate."

Ivan Cavalli
Manager, Transportation Sector
KPMG in Italy

25 | Hungary

25 Policy and legislation
24 Technology and innovation
21 Infrastructure
28 Consumer acceptance

The Hungarian government's enthusiasm for AV technology was demonstrated in May 2019, when Prime Minister Viktor Orbán opened the first phase of the 265-hectare ZalaZone AV testing ground near Zalaegerszeg in western Hungary, with the final phase planned for completion in 2020. The track will be linked to the new M76 smart expressway which will incorporate contactless charging of EVs, allowing real road tests.[107] The testing ground will also have some unique features, including a highway module that will allow for medium and high-speed tests reflecting real circumstances.[108] Magyar Telekom, a subsidiary of Germany's Deutsche Telekom, used the opening to demonstrate how AVs using newly-live 5G base stations to communicate could park automatically using a system designed by T-Systems Hungary, another Deutsche Telekom unit.[109] Hungary is one of just two countries given the top rating for having an AV-focused government agency, the other being Singapore.

Other German companies have announced new research and development (R&D) facilities in Hungary. Vehicle parts maker Continental, which already has seven factories in the country, announced in February 2019 an R&D center for AVs in Budapest employing 100 hardware and AI software specialists.[110] Industrial group Thyssenkrupp is developing AV steering systems at its Budapest R&D center, brake specialist Knorr-Bremse is working on autonomous trucks and technology group Bosch is developing sensors.[111]

British companies are also involved in developing AV work in Hungary, with vehicle maker Jaguar Land Rover opening a technical engineering office in Budapest in early 2019 with 100 staff.[112] In November 2019, UK telecoms provider Vodafone, with Hungarian AV technology company AImotive and Dutch digital mapping specialist Here Technologies, announced a pilot of an automated valet parking system, working in parking garages in Budapest.[113] AImotive's partners also include vehicle makers PSA Groupe and Volvo and technology companies including Nvidia and Samsung.[114]

"We will be more on the supply side than the demand side," says Márton Zsótér, Manager of Infrastructure, Transportation and Energy Advisory, KPMG in Hungary, as the country is a small market compared with many other European countries. Many German vehicle companies have established manufacturing in Hungary, including Audi and Mercedes-Benz, and the country is now moving from assembly to higher-value work: "Compared to the last few decades, the focus is on research and development rather than assembly," he says. "Because of the continuously evolving research infrastructure and competencies, I think Hungary is on a good path to become a key player in AV development."

AV-focused agency top five

Source: KPMG International (2020)

> "Compared to the last decade, the focus is on research and development rather than assembly."

Márton Zsótér
Manager of Infrastructure
Transportation and Energy Advisory
KPMG in Hungary

26 | Russia

26	26	27	20
Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance

There is significant interest in Russia on developing AVs from both government and some companies. Russia's government is working to expand the country's existing AV trials on public roads, which started in late 2018. As well as being expanded to up to 11 new areas, it has asked companies to develop plans for truly driverless test vehicles, rather than the existing ones that have someone ready to take the wheel.

Yandex, the Russian technology company, is among those pushing for fully driverless AVs. In March 2019 it agreed to jointly develop control systems for level 4 and 5 AVs with South Korea vehicle maker Hyundai, with the initial aim of producing a driverless prototype based on one of the company's production model cars.[115] The company has already run tests in Israel and robotaxi services in the Russian cities of Innopolis and Skolkovo, and in November 2019 it announced plans for small autonomous robots designed for local deliveries in cities called Yandex Rovers, named after the rover vehicles used exploring, Mars which they resemble.[116]

In November 2019 Cognitive Technologies, whose clients for AV technology include Hyundai, formed a new company Cognitive Pilot, which is 30 percent owned by state bank Sberbank.[117] In February 2020 its chief executive Olga Uskova said she is planning either an initial public offering or further investment after 2023.[118]

However, Russia has the lowest access to the latest technology of any of the countries and jurisdictions in the AVRI, according to the World Economic Forum's *Executive Opinion Survey.* It also has the second lowest adoption of cloud, AI and IoT technologies, joint-second slowest mobile speed and second poorest road quality.

Sergey Kazachkov, Partner, KPMG in Russia and the CIS, says that the Russian government believes AVs to be a promising technology and follows a stage-by-stage roadmap for the introduction of autonomous cars in Russia approved in 2018. The largest state-owned automotive groups and banks together with major private technology companies participate in the development of software and technological solutions.

"The momentum we are seeing here leads me to believe that Russia will continue to be one of the top 30 leaders to introduce autonomous cars in everyday life."

Sergey also notes that the largest domestic manufacturer of passenger cars will have to cooperate with global players as it is significantly lagging behind in terms of their own AV solution development.

However, the largest Russian manufacturers of trucks, such as Kamaz, and light commercial vehicles, for example, GAZ, are far ahead and already testing their AV technologies and solutions in testing areas.

Mobile connection speed bottom five

Source: Ookla Speedtest (March 2020)

> "The momentum we are seeing here leads me to believe that Russia will continue to be one of the top 30 leaders to introduce autonomous cars in everyday life."

Sergey Kazachkov
Partner
KPMG in Russia and the CIS

27 | Chile

24 Policy and legislation
27 Technology and innovation
26 Infrastructure
25 Consumer acceptance

Chile, a new entrant to the AVRI, has been using AVs in mining for more than a decade. Rodolfo Echeverria, Director, Infrastructure and Government, KPMG in Chile, says that the government-owned Codelco's Gabriela Mistral copper mine introduced 18 autonomous GPS-guided trucks in 2008. They have improved the efficiency to the mining process as they are used for 17 hours a day compared with 14 or 15 for a human-driven vehicle.[119] These vehicles are being introduced underground through the installation of positioning equipment.

In January 2020 Chile started what it believes is the first AV pilot project in Latin America, supported by the ministry of transportation and telecommunications and the Inter-American Development Bank. The trial uses an EV minibus running on a 1km circuit around O'Higgins Park in central Santiago, not on public roads, with French transport operator Transdev and the University of Chile as technology partners.[120] Transdev has found that the high levels of solar radiation resulting from Santiago's relatively low latitude impact battery performance.

"We have huge use in the mining sector, but public use will take more time," says Echeverria. "The Chilean government's vision to embrace disruptive technology and take leadership on technology and communications in the region is one of the country's strengths." He adds that the country also benefits from an active ecosystem of technologists, companies, and universities.

Work will be required to improve the country's technology development, including the lowest marks on measures of innovation capability and cybersecurity and the second lowest score for mobile connection speed. The government has ambitious plans to improve connectivity through a 24,000km (15,000 miles) undersea cable linking Chile to Asia, with finance for feasibility studies published in July 2019;[121] the nearly-completed 4,000km Fibra Óptica Austral submarine and land cable that will connect two southern cities, Puerto Montt and Puerto Williams; and the 10,000km Fibra Óptica Nacional, announced by President Sebastián Piñera in May 2019 to link 13 of Chile's 16 regions.[122]

There is also significant work on EVs, with Santiago already having 200 electric buses in operation; plans by Italian energy group Enel to establish 1,200 public charging points along 5,000km of roads from Arica in the north to Punta Arenas at the southern tip of the country; and the government's intention to make all public transport electric by 2050, along with 40 percent of private vehicles.

There are no specific regulations for AVs and Echeverria says a simple, streamlined process to authorize tests and single points of contact would be useful. He also believes that the government should consider investing more in training so that the country will be ready when it requires further analysis and assessment for planning and, eventually, implementation of both AVs and transport infrastructure required to support them. The Chilean government's use of public-private partnerships, including in building and operating roads, may assist in the introduction of AV infrastructure and as a model for working with industry.

Innovation capability bottom five

Source: World Economic Forum, *Global competitiveness index* (2019)

> "The Chilean government's vision to embrace disruptive technology and take leadership on technology and communications in the region is one of the country's strengths."
>
> **Rodolfo Echeverria**
> Director, Infrastructure and Government
> KPMG in Chile

28 | Mexico

Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance
29	29	28	27

Mexico is assessed as lowest on industry partnerships and second lowest on AV regulations, pilots and having an AV-focused agency, as well as being second-lowest on government's readiness for change.

This reflects that Mexican implementation of AVs, along with other new transport and clean energy technologies, is on hold under the current government, according to Ignacio García de Presno, Partner, Infrastructure and Global Group, KPMG in Mexico. It has instead focused on older industries, having in July 2019 awarded contracts to build a new US$8 billion oil refinery in the port city of Dos Bocas.[123] "We're trying to restore what we've got, rather than develop new things," says de Presno. Despite pressure from the private sector, any change is unlikely until the next federal election in 2021.

He sees good potential for Mexico to develop use of AVs, given its proximity to the United States. "Sooner or later we will catch up, as we share a long border and are one of its main trading partners," he says. "The first step has to come from the government, not just in this area but in many others. It needs to lay the ground so that the private sector and universities can work on it."

Industry partnerships bottom five

Source: KPMG International (2020)

> "The government needs to lay the ground so that the private sector and universities can work on it."

Ignacio García de Presno
Partner, Infrastructure and Global Group
KPMG in Mexico

29 | India

28	28	29	30
Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance

In 2017, India's transport minister Nitin Gadkari ruled out the use of driverless cars on the basis they would take away jobs from the 2.2 million commercial drivers working in the country.[124] The country gets the lowest scores for many measures in the AVRI, including three in the policy pillar, on AV regulations, having an AV department and government-funded pilots.

India's government is focused on developing the use of EVs before it tackles AVs, although this presents its own challenges, according to Sameer Bhatnagar, Partner, Transport and Logistics, KPMG in India. EV batteries typically rely on lithium of which China is the largest supplier in the world, presenting strategic concerns for the government. One option could be to use alternative power sources such as fuel cells or hydrogen.

A shift to EVs, which require less maintenance than conventional vehicles as they have fewer moving parts, would also be likely to lead to fewer jobs in manufacturing, maintaining and repairing motor vehicles. India is the fifth largest producer of motor vehicles globally, making 4.5 million in 2019.[125] There are some 400,000 Indians employed in factories making, maintaining and repairing motor vehicles according to official figures[126] and many more in informal repair shops.

Bhatnagar says that some agencies are working to develop electric charging infrastructure in alignment with the FAME Scheme, (adopted in 2015 for EVs), but it would be desirable for the government to develop a national strategy in association with the country's states for AVs as well. As well as employment, EVs and AVs could impact areas such as insurance.

On the commercial side, India's IT sector looks set to benefit from the introduction of AVs globally: "Technology companies are looking at migrating their software skills to help program AVs, not only for India, but also for companies elsewhere in the world," says Bhatnagar.

He adds that adoption of AVs in India is likely to start with commercial applications such as autonomous or remote-controlled vehicles in warehouses, ports and potentially on farms. Using such equipment would improve performance and for agriculture could reduce dependence on migrant labor as has been manifested as a key need in India due to the COVID-19 pandemic, during which the migrant labor returned to their homes.

AV regulations bottom five

Source: KPMG International (2020)

> "Technology companies are looking at migrating their software skills to help program AVs, not only for India, but also for companies elsewhere in the world."

Sameer Bhatnagar
Partner, Transport and Logistics
KPMG in India

30 | Brazil

Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance
30	30	30	29

Brazil's government is doing little to encourage adoption of AVs, reflected in its position at the bottom of the AVRI rankings. This is despite the country's enthusiasm for new technologies and services such as ride-hailing, says Mauricio Endo, Head of Government, KPMG in Brazil and South America. "We still don't see any public policy around creating an avenue for AVs to start operating in the cities," he says.

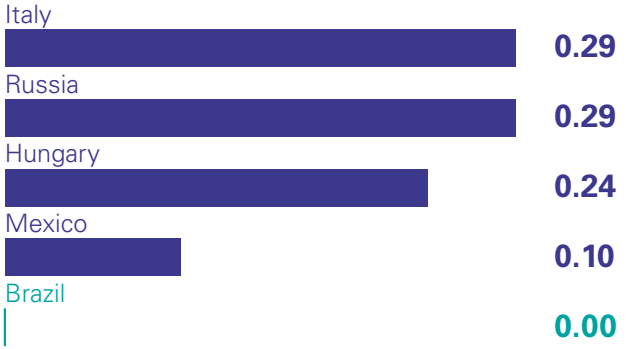
Brazil's Rota 2030 vehicle efficiency and safety program, launched in 2018, provides incentives to move away from traditional engine types to hybrids or EVs, although this is not its main aim. October 2019 saw the launch of a small fleet of Renault Twizy electric cars along with charging points in Brasilia, allowing public servants to travel between government buildings in a more carbon and cost-efficient way than before.[127]

The introduction of 5G mobile services, which will provide better networking for AVs, will follow the Brazilian government's planned auction of spectrum, likely to be one of the world's largest so far. It has been planned for late 2020, although in April telecoms providers suggested it be postponed due to the impact of coronavirus on the country's economy.[128]

The private sector is more active, although is focusing on uses off public roads. In January 2020, Brazilian vehicle maker Hitech Electric launched what it called the first AV developed in the country. The two-seater electric e.coTech4, which can reach speeds of 50kph (31mph), is initially available only for corporate lease in closed areas such as industrial sites, university campuses and resorts.[129] In October 2019 Brazilian mining company Vale said it would start testing use of autonomous haulage trucks at its Carajás site, the world's largest open-pit iron ore mine. It had already transferred all haulage work at its Brucutu mine to 13 autonomous trucks, with in-vehicle operators retrained to work from the control room.[130] EmbraerX, a subsidiary of the Brazilian aerospace company, is working on unmanned aircraft and announced an agreement on commercial air cargo with US startup Elroy Air in January 2020.[131]

Endo says that the government could build on this by working to establish an autonomous route for freight, using public roads, such as between Sao Paulo and another major city. "If the government decided to set up truck corridors that would be very helpful," he says.

Government readiness for change bottom five



Source: KPMG International (2020)

> "We still don't see any public policy around creating an avenue for AVs to start operating in the cities."
>
> **Mauricio Endo**
> Head of Government
> KPMG in Brazil and South America

Cities to watch

The following five cities have been profiled based on interesting work on AVs by their local and municipal governments. They have not been ranked against each other or against other cities not profiled here.

Beijing, China

China nationally set a goal in 2016 of mastering the overall technology of intelligent assisted driving and various key technologies, and establishing an independent research and development system and production capacity for intelligent connected vehicles by 2020.

As well as being the capital where these decisions are taken, Beijing has taken a leading position among China's cities. In December 2017, it became the first Chinese city to authorize testing of AVs on public roads. The regulations were co-drafted by Beijing's transportation commission, traffic management bureau and economy and information technology commission, which together will be responsible for overseeing the industry as it expands in the capital. The regulations have served as a model for other Chinese cities.[132]

The regulations require that companies must first complete tests in designated closed zones before they can conduct open road tests. When the guidelines were first issued, Beijing earmarked 33 road sections with a total length of 105km (65 miles) for testing AVs, at the time the most among all Chinese cities.[133] The number of sections as well as the total length of roadways has since increased.

In December 2019, Beijing began to allow the testing of AVs with passengers, with technology company Baidu the first company to obtain permission to test 40 vehicles. In May 2020, AV provider Pony.ai became the first start-up approved to test passenger-carrying AVs on open roads.

Apart from Pittsburgh in the US, Beijing is one of the few cities to require AV testers to disclose the miles they have driven, the size of their vehicle fleets and the disengagements they have experienced. Thirteen Chinese companies drove 77 autonomous vehicles 1.04 million km on Beijing roads during 2019, up from the 153,600 km eight firms drove in 2018.[134]

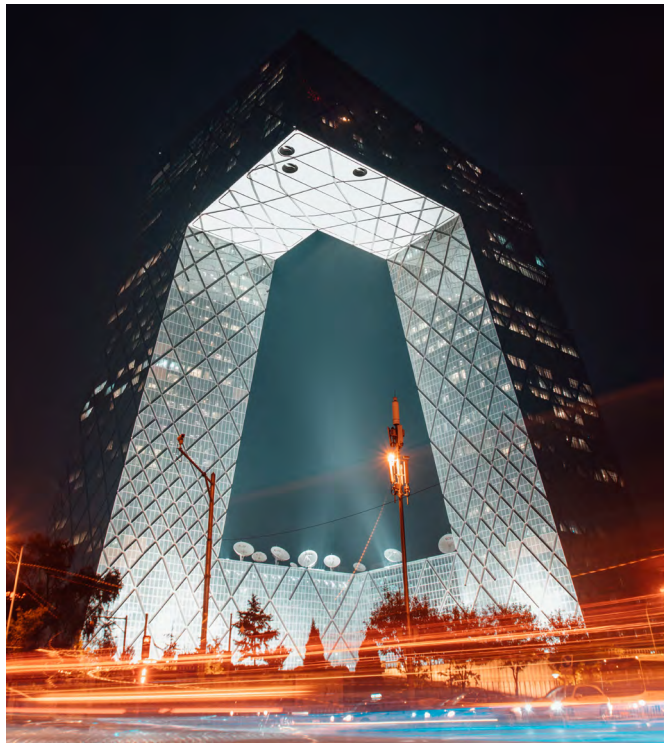
In China, AVs have been used in the fight against the coronavirus pandemic by transporting medical supplies and food to healthcare professionals and the public in infected areas and disinfecting hospitals and public surfaces to reduce the spread of the coronavirus. Baidu partnered with Neolix, a local self-driving startup, to deliver food and supplies to staff at the Haidian Hospital.[135]

The Beijing 2022 Organizing Committee is hoping to make the 2022 Winter Olympics and Paralympics the most technology driven in history, with AVs planned to play a huge role. In order to achieve this goal, $50 million is being invested to develop a 100 square km testing zone.[136]

Importance of AVs to Beijing

Today	In three years
Moderately important	Extremely important

Source: ESI Thoughtlab (2020)



Detroit, United States

Detroit has been able to use AVs to help fuel the economic resurgence of the city. Multiple companies are currently testing AVs in the city, including AV startups Argo AI and May Mobility, vehicle maker Ford and Google's sister company Waymo. In addition, dozens of AV-related startups are coming to the city from all over the world in the hopes of partnering with big American car companies.[137]

State and local governments are helping to market Detroit's talent pool to firms that might not think otherwise of locating in the Motor City, the name Detroit gained in the early 20th century as the US's leading location for car manufacturing. In late 2017, the Detroit Regional Chamber and Michigan's Economic Development Corporation launched the PlanetM Landing Zone. This has attracted 56 members, including German car part supplier Bosch and US ride-hailing company Lyft, as well as startups including Derq, a UAE company focused on pedestrian safety.[138]

The state of Michigan has launched the Michigan Office of Future Mobility under the Department of Labor and Economic Opportunity, which is charged with leading the strategic coordination of all mobility-related initiatives across economic development, workforce, and infrastructure efforts in the state to secure Michigan's status as a global leader in autonomous, connected, electric, and shared future mobility. The department also hosts the Michigan Council on Future Mobility and Electrification.[139]

While other US cities including Pittsburgh and San Francisco have seen research, developing and testing of AVs generate economic and employment benefits, Detroit has been able to leverage its Motor City legacy to become the world leader in AV manufacturing as well. Waymo repurposed an abandoned vehicle factory to open the world's first dedicated AV manufacturing plant, which will employ more than 400 people when fully operational.[140] Both Ford and GM have also announced large investments to develop AV and EV manufacturing in the city.[141]

The city is also taking steps to make sure that it is able to provide the workforce required by AV companies. The Michigan Mobility Institute is retraining vehicle industry workers with skills in AI, robotics, cybersecurity and other relevant fields, and is partnering with community colleges, trade schools and online learning platforms to help develop new skilled-trade including AV repair, connected fleet management and AV safety drivers. Together with university partners, the Institute has developed a Master of Mobility degree program, which will focus on developing a systems-level understanding across areas including software development, AI machine learning and data sciences.[142]

Importance of AVs to Detroit

Today	In three years
Very important	Very important

Source: ESI Thoughtlab (2020)

Helsinki, Finland

Helsinki is a global leader in the smart city movement and is taking a holistic approach to become a transportation trendsetter through the integration of mobility as a service, EVs and AVs, with goal of the city becoming carbon neutral by 2035.

Helsinki was one of the first major cities to appoint a chief design officer when it established the Helsinki Lab in 2016, with the job of making design, knowledge, digitalization and interaction an integral part of city development.[143] The role includes overseeing cross-cutting efforts to integrate AVs into the urban environment.

The city has taken other major steps to encourage innovation. Forum Virium Helsinki is a city-owned innovation company which focuses on transportation innovation projects, open data and smart mobility. It works with companies, universities, other public sector organizations and residents with the aim of making Helsinki the most functional smart city in the world, with more than 750 companies and 170 research facilities involved.[144] As well as AVs, it is supporting the development of an autonomous ship.

As part of the work of Forum Virium, Helsinki is a major contributor to the Fabulos (future automated bus urban level operation system) project, a development program with six other European cities to develop solutions for AVs. It aims to deliver a systemic proof-of-concept for using AV minibuses to provide the 'last mile' linking existing urban public transport systems to people's homes and workplaces.[145]

On regulation, the city's traffic and street planning office works closely with different city units, the traffic safety agency, and other public entities. In general, regulators in Finland are agile and Finnish legislation makes it possible to carry out versatile autonomous tests with different forms of transport with test permits able to be obtained effortlessly, and with easy interaction with the authorities.

Helsinki's first AV pilot in 2016 involved the establishment of a very short bus route in the city's waterfront district, with several other pilots of varying distances and durations having followed. April 2020 saw three self-driving vehicles starting to serve a circular route including Pasila train station in Helsinki, part of the Fabulos project, although they initially ran without passengers as a result of the coronavirus crisis.[146] The project aims to get its service commercially implemented by the city council and HSL, the regional transport authority.

Importance of AVs to Helsinki

Today	In three years
Moderately important	Very important

Source: ESI Thoughtlab (2020)

Pittsburgh, United States

AVs represent a fast-growing industry for Pittsburgh, which hosts a strong list of companies in the field. US ride-hailing company Uber, US AV startups Argo AI and Aurora and Irish AV technology specialist Aptiv are present in the city, building on decades of research on AI and robotics research at Carnegie Mellon University. As of April 2019, the four companies and the university were testing 55 level 4 self-driving cars, with such activities have generated over 1,300 local jobs.[147]

In March 2019, the City of Pittsburgh issued an executive order that lays out the objectives and expectations for testing of AVs in the city, which established an AV department within the city's Department of Mobility and Infrastructure. Representatives from the five organizations involved in AV testing in the city were present at the signing ceremony, demonstrating the strong emphasis on partnership that is a hallmark of Pittsburgh's approach. Its principles included instituting transparent lines of communication between the city and those testing AVs; annual reports on the implementation of AV policies; promoting automated driving systems that encourage high vehicle occupancy with lower or no emissions, and lower cost and equitable transportation options; and engaging industry leaders and community stakeholders to collaboratively facilitate the further development and deployment of AV technology.

The council has taken a proactive approach on how AVs may change the city. In May 2019 it won a US$410,000 award from the Knight Foundation to help demystify AV technology for the public, designed to help ensure that the public understands the technology, its limitations and opportunities, and funding a director who will organize discussions across the city to help inform city policy.[148]

Pittsburgh also provides an example of what exposure to operating AVs can have on public perceptions. The city's cyclist advocacy group BikePGH conducted surveys in 2017 and 2019 on opinions of AVs. In the most recent survey respondents used words like "unremarkable" or "nothing notable" to describe their interactions with AVs and just over half said they had shared the road with such a vehicle, suggesting that interacting with AVs is becoming commonplace and an accepted part of urban life. Respondents felt safer sharing the road with AVs than cars driven by human drivers, and felt that AVs have the potential to reduce injuries and fatalities, with 72 percent feeling that AVs will significantly or slightly improve safety on the streets. However, although 70 percent of respondents approved of the Pittsburgh being a proving ground for AVs, some also felt that since the companies are not paying to run tests on public streets they should contribute funds to help support public transport, cycle lanes, sidewalks and road improvements.[149]

Seoul, South Korea

In December 2019, South Korean vehicle maker Hyundai Motor started tests of AVs on the capital city's streets, initially with six vehicles on 23 roads. It plans to expand its fleet to 15 vehicles, all hydrogen electric driven, by 2021. As part of the agreement, the city will provide the vehicles with traffic data every 0.1 seconds and will also share its data with schools and companies that want to test AV technology.[150]

The agreement with Hyundai built on other city projects. In June 2019, the Seoul Metropolitan Government announced the completion of what it described as the world's first 5G convergence AV test bed at the Sangam Digital Media Center in the west of the city. This allows self-driving cars to use 5G mobile networking and vehicle-to-everything (V2X) technology on a normal road. The plan for the AV test bed is to promote convergence between 5G and V2X, which includes communication between vehicles and other vehicles (V2V); vehicles and infrastructure (V2I); and vehicle and people (V2P).[151]

The Sangam Digital Media Center has also been testing unmanned delivery robots built by Unmanned Solutions, a locally-based startup. As part of a one-year city-funded pilot that began in October 2019, four-wheeled EVs are being used to move supplies from trucks on a main road to restaurants and shops in car-free zones in Sangam. During the trial, the vehicles are traveling across pedestrianized areas such as parks, plazas and streets that are closed to other vehicles.[152]

In May 2020, the city's government launched use of three AV buses, four cars and three delivery robots on actual roads in Sangam as part of its smart mobility project. These will be used for contactless car-sharing, automatic parking and deliveries to locations that normal cars cannot access. Residents of Seoul will be able to apply for free rides on the buses, which will travel along a 3.3km (two miles) route six days a week, through the city's Topis traffic information website. The project partners involves Unmanned Solutions, AV robot builder Dogugonggan and the city's Yonsei University.[153]

Importance of AVs to Seoul

Today	In three years
Very important	Very important

Source: ESI Thoughtlab (2020)

The road to ubiquity

In 2019, the second edition of the AVRI concluded with 'The road ahead', actions that national governments could take to improve their readiness for driverless vehicles.

Many countries and jurisdictions now have some of the appropriate legislation and regulations in place to enable AVs, although much of the hard work on national implementation remains — including putting infrastructure in place, establishing data policies and protocols, and setting policies on licensing and insurance.

Many of the most exciting developments in the third edition of the AVRI are taking place at a local level, led by cities, municipalities or states. With shared road transport including taxis and buses often the responsibility of local rather than national governments, it is clear that for AVs to become ubiquitous, they will need support at a local level as well as nationally.

Key insights for national and local governments

Shared AV vans and buses may be at least as important as private driverless cars. Numerous localities are prioritizing driverless minibuses, for instance, to extend the range of existing public transport (Oslo in Norway and others), provide on-demand services to residents of a retirement village (Coffs Harbour in Australia, through the New South Wales transport authority) and to move tourists through an ecologically-delicate national park (Lanzarote in Spain). The technology is maturing with a range of suppliers at all levels of the value chain, meaning that local governments can bring them into use more quickly.

AVs can be used to help transform an area's transport. The COVID-19 pandemic led to huge falls in use of all kinds of transport and several localities have not let this crisis go to waste. Many cities around the world have reconfigured roads, including Calgary in Canada and Minneapolis and Portland in the US, which have limited access to motorized vehicles on some roads to encourage walking and cycling, and Berlin in Germany, Bogotá in Colombia and Mexico City which have expanded cycle networks.[154] The pandemic provides an opportunity for city and municipal governments to encourage people to change the way they travel, including making greater use of AVs, whether buses or otherwise. There are also further opportunities to expand the use of AVs for freight and in closed environments such as industrial, port and mining areas.

The safety case for AVs is getting stronger. The reputation of driverless cars was greatly damaged when a test vehicle operated by Uber killed a pedestrian in Tempe in Arizona in March 2018. However, an accident involving an autonomous minibus that took place in Vienna in June 2019 may provide valuable insight. The pedestrian, who was looking at a phone and wearing headphones, received only minor injuries after the bus stopped just 1.6 seconds after detecting her and the city's public transport provider Wiener Linien restarted its trial a few days later. While no form of transport can be entirely without risk, governments around the world have the opportunity to use AVs to make their roads significantly safer.

AVs will need both local and national government focus and support to become ubiquitous. Cities, municipalities and states are naturally focused on the particular challenges and opportunities of their area. Many of the AVRI's top performers are urban-dominated countries, including Singapore (which as a city-state combines both layers of government) and the Netherlands. Strong cities such as Detroit and Pittsburgh are achieving a lot despite less US federal involvement. However, the ideal is for both national and city governments to have a strong AV focus and work together, with national governments providing the enabling policies and cities increasing public acceptance by providing useful, and innovative new services.

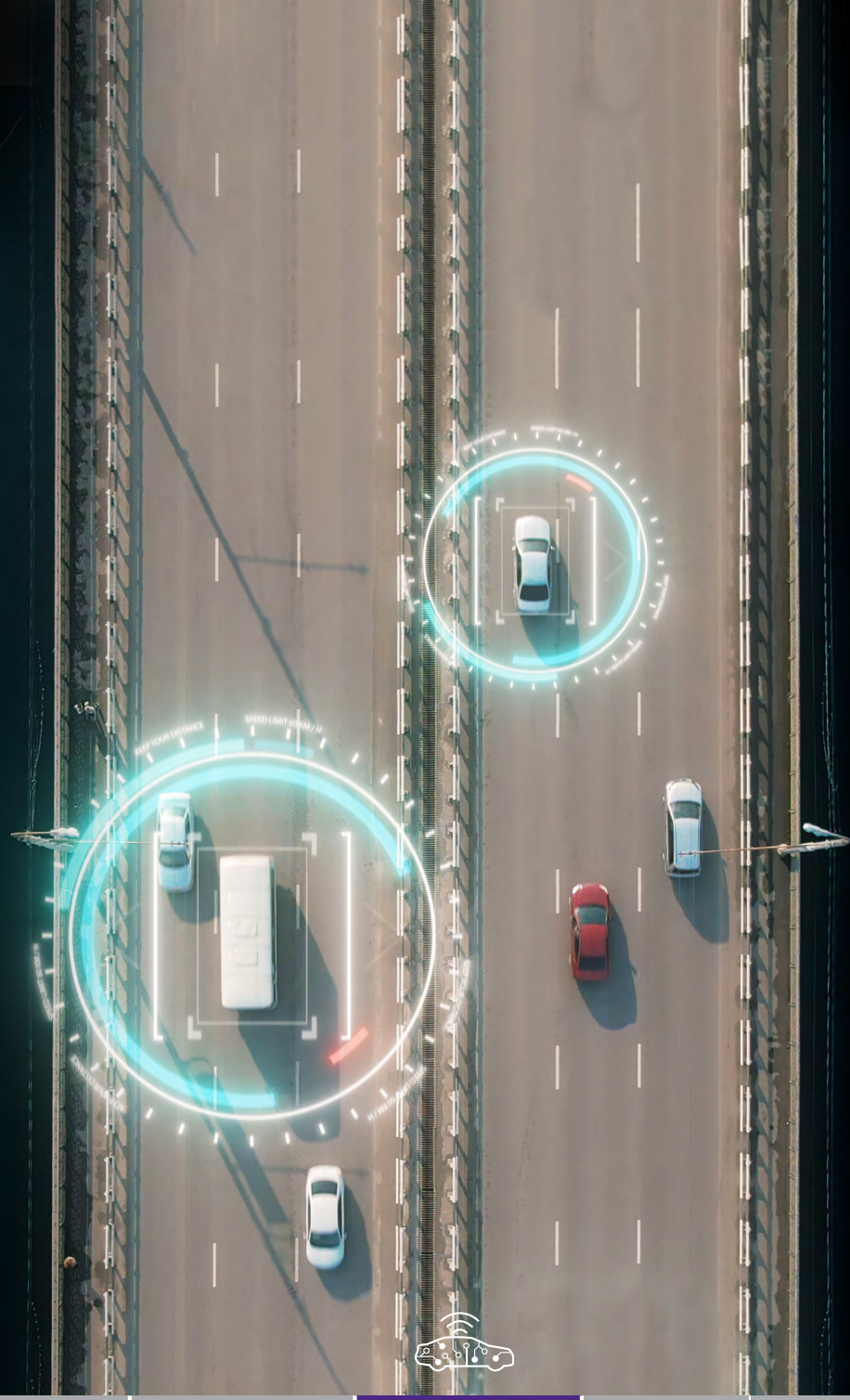
Appendix: results and methodology

The 30 countries and jurisdictions have been assessed on 28 different measures, gathered into four pillars — **policy and legislation, technology and innovation, infrastructure** and **consumer acceptance**. Four measures are scored for this index by KPMG International and ESI ThoughtLab, a US-based research firm, which used publicly available information, including media reports, press releases and other material. A further 24 variables draw on existing research by KPMG International and other organizations, with full details below.

The variables under the four pillars are combined to arrive at an aggregate score for each. Variables are given equal weight in arriving at the overall pillar score, with the exception of the mobile connection speed and broadband measures in the infrastructure pillar which both have half the weight of other measures to arrive at an overall score for this particular area. Before the data is combined it is normalized, as the variables have different measurement units, using the min-max method. This converts the variables to a range between zero and one, by subtracting the minimum value and dividing by the range of the variable values. Therefore the top-ranked country receives one and the bottom country zero.

Pillars have differing number of variables, so each pillar score is scaled to give them the same maximum possible value. This means that each pillar has equal weight in the overall score for each country and jurisdiction.

ESI ThoughtLab



Policy and legislation

Overview

- As in previous editions, Singapore leads this pillar overall, as well as gaining the top scores on five of its seven measures. These include measures of government change readiness and an assessment of the future orientation of government, the latter a new measure to the AVRI, where on both the city-state is the sole leader.
- Four countries receive the top rating in this report's assessment of AV regulations: Australia, Finland, Singapore and the Netherlands. Hungary and Singapore receive the highest rating for having a single government organization for AV work.
- Five countries and jurisdictions gain the highest rating from this report's assessment of government-funded AV pilots: Canada, the Czech Republic, Singapore, South Korea and Taiwan.
- The UK retains its second place on this pillar and leads on the measure assessing the data-sharing environment.

Methodology

The pillar is calculated from seven equally weighted measures, one of which is new for the 2020 edition of the index and one which has replaced a similar measure.

AV regulations, **government-funded AV pilots** and **AV-focused agency**: each of these three factors is scored out of seven for this index based on a review of media articles, government press releases and government regulations.

On AV regulations, countries that have regulations that are supportive of AV use and place few restrictions on when, where and how testing of AVs may occur are scored higher and countries that place greater restrictions on testing are scored lower. The maximum score has been awarded to Australia, Finland, the Netherlands and Singapore. The lowest score goes to India, followed by Mexico and Brazil.

A similar approach is taken for government-funded AV pilots. The maximum score is awarded to Canada, Czech Republic, Singapore, South Korea and Taiwan. The lowest score goes to India, followed by Brazil and Mexico.

With the AV-focused agency variable, governments that spread the responsibility for AVs across a large number of government entities are given lower marks; those that take the most common approach, of placing responsibility in an existing agency, gain middling marks; and those establishing an AV or transportation technology and innovation-focused agency that has sole responsibility gain the highest marks. As well as providing innovators with a single point of contact, such focus demonstrates a government's commitment. Hungary and Singapore are awarded maximum marks. India gets the minimum score, followed by Brazil and Mexico.

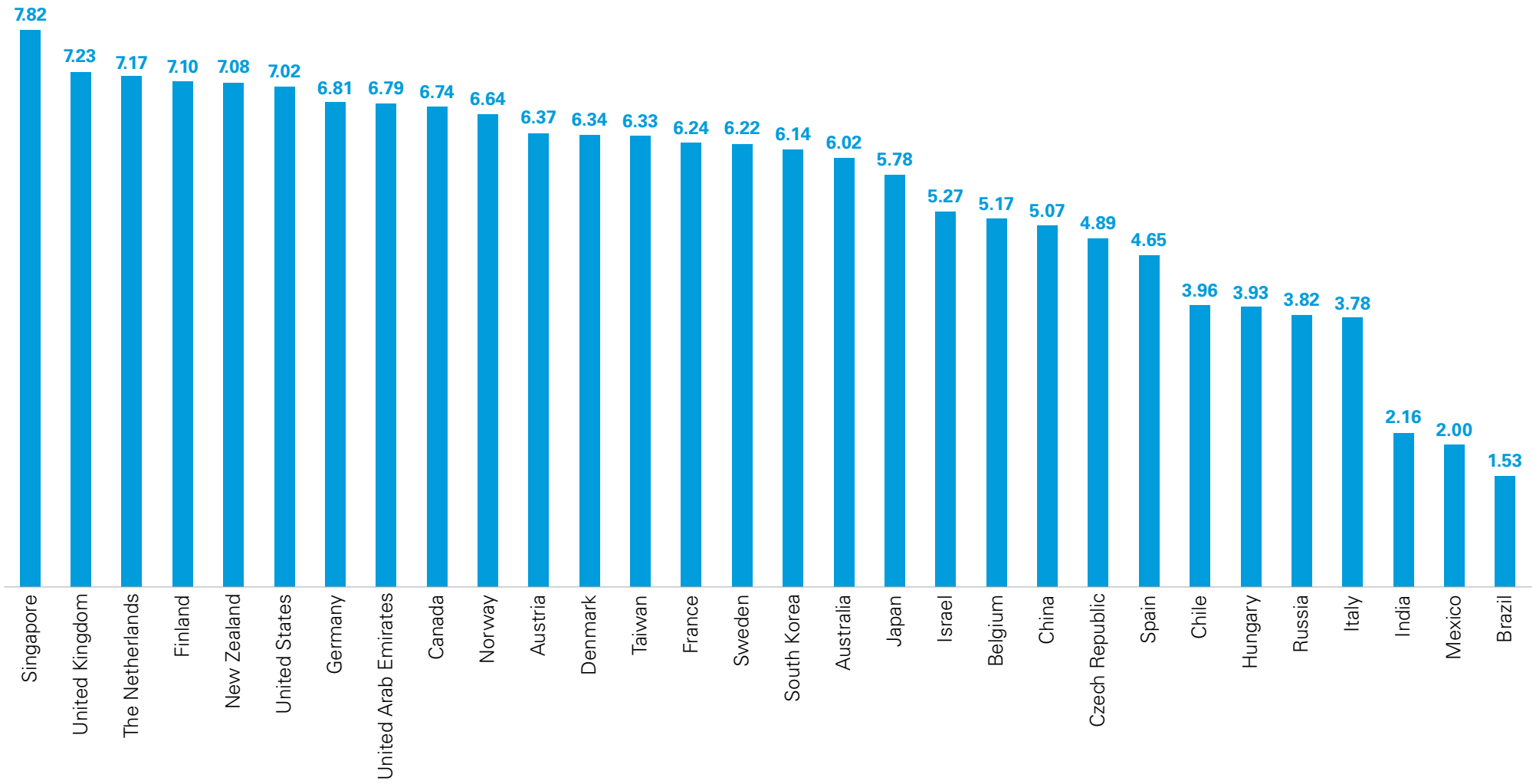
Government readiness for change: scores are based on KPMG International's 2019 *Change readiness index*.[155] This is a composite index that assesses regulation, government strategic planning and the rule of law among other measures. Singapore receives the highest score, followed by the UAE and Sweden, while Brazil gets the lowest, followed by Mexico and Hungary.

Future orientation of government and **efficiency of the legal system in challenging regulations:** both from the World Economic Forum's *Global competitiveness index* for 2019, as judged by business executives in each country.[156] Replacing a measure that is no longer published on the effectiveness of the legislative process, the future orientation of government is based on the average of measures on policy stability, government's responsiveness to change, the adaptability of the country's legal framework to change and the government's long-term vision. Singapore, the UAE and the US receive the highest scores, while Italy, Brazil and Spain receive the lowest.

The measure on challenging regulations through the legal system is included to gauge the ability of AV manufacturers and others to challenge unfavorable government rules. On this, Finland, the Netherlands and the UAE received the highest scores, while Hungary, Italy, Brazil received the lowest scores.

Data-sharing environment: this measure is based on data also used in the 2019 edition, from the World Wide Web Foundation's *Open data barometer* for 2016, which covers 29 of the countries in this edition.[157] While no update has been released, this data was used in the 2019 edition of the Network readiness index, reflecting its currency.[158] Countries adopting open and shared data approaches score higher, as this enables greater collaboration between government and private industry to encourage AV development. Taiwan was not included in the *Open data barometer*, but separate research in 2016 by the Open Knowledge Foundation rated Taiwan as first among a group of 94 countries and jurisdictions on its use of open data.[159] To reflect this, Taiwan has been given the average score of Australia, Great Britain and France, its closest peers in the Open Knowledge Foundation research. As a result, the UK, Canada and Taiwan rank highest while China, Hungary and the UAE rank lowest.

Pillar 1 scores: Policy and legislation



Policy and legislation pillar scores breakdown by variable

	Position	AV Regulations	Government-funded AV Pilots	AV-focused agency	Future orientation of government	Efficiency of legal system in challenging regulations	Government readiness for change	Data-sharing environment	Pillar 1 score (unadjusted)
1	**Singapore**	1.000	1.000	1.000	1.000	0.673	1.000	0.411	**6.084**
2	**United Kingdom**	0.929	0.857	0.857	0.534	0.668	0.780	1.000	**5.626**
3	**The Netherlands**	1.000	0.929	0.714	0.639	0.825	0.780	0.688	**5.576**
4	**Finland**	1.000	0.857	0.714	0.718	1.000	0.780	0.451	**5.521**
5	**New Zealand**	0.929	0.714	0.929	0.573	0.792	0.829	0.743	**5.509**
6	**United States**	0.857	0.929	0.714	0.763	0.792	0.634	0.771	**5.461**
7	**Germany**	0.786	0.857	0.857	0.604	0.747	0.829	0.621	**5.301**
8	**United Arab Emirates**	0.857	0.714	0.929	0.880	0.865	0.951	0.081	**5.278**
9	**Canada**	0.786	1.000	0.714	0.502	0.614	0.756	0.870	**5.242**
10	**Norway**	0.929	0.857	0.643	0.575	0.629	0.854	0.674	**5.161**
11	**Austria**	0.857	0.857	0.929	0.502	0.568	0.610	0.629	**4.952**
12	**Denmark**	0.714	0.643	0.857	0.589	0.666	0.829	0.633	**4.931**
13	**Taiwan**	0.857	1.000	0.786	0.334	0.425	0.659	0.860	**4.920**
14	**France**	0.786	0.857	0.714	0.481	0.615	0.585	0.815	**4.854**
15	**Sweden**	0.714	0.714	0.714	0.564	0.624	0.878	0.625	**4.834**
16	**South Korea**	0.857	1.000	0.857	0.488	0.346	0.463	0.766	**4.777**
17	**Australia**	1.000	0.571	0.714	0.409	0.516	0.707	0.765	**4.683**
18	**Japan**	0.571	0.857	0.571	0.505	0.642	0.659	0.691	**4.496**
19	**Israel**	0.714	0.786	0.643	0.532	0.603	0.488	0.331	**4.097**
20	**Belgium**	0.929	0.714	0.714	0.271	0.565	0.512	0.319	**4.024**
21	**China**	0.786	0.929	0.643	0.490	0.535	0.561	0.000	**3.944**
22	**Czech Republic**	0.857	1.000	0.714	0.186	0.222	0.512	0.309	**3.800**
23	**Spain**	0.857	0.571	0.714	0.163	0.322	0.317	0.668	**3.614**
24	**Chile**	0.429	0.571	0.429	0.435	0.435	0.439	0.346	**3.083**
25	**Hungary**	0.643	0.857	1.000	0.266	0.000	0.244	0.046	**3.056**
26	**Russia**	0.571	0.286	0.857	0.367	0.240	0.293	0.360	**2.973**
27	**Italy**	0.857	0.643	0.643	0.000	0.056	0.293	0.452	**2.943**
28	**India**	0.000	0.000	0.000	0.536	0.514	0.341	0.288	**1.679**
29	**Mexico**	0.143	0.143	0.143	0.168	0.194	0.098	0.670	**1.557**
30	**Brazil**	0.286	0.143	0.143	0.011	0.119	0.000	0.488	**1.190**

Technology and innovation

Overview

- As in the second edition of the AVRI Israel leads this pillar, leading on AV company headquarters and investments in AV-related firms, both of which are adjusted for population.
- The US moves from third in the last AVRI to a close second. It leads on industry partnerships and a new measure that assesses progress on cloud computing, AI and IoT.
- Japan leads on number of AV-related patents as in previous editions, both on absolute number on when adjusted for population, the latter being the measure used in the index.
- The UK leads a new measure assessing cybersecurity, Finland continues to lead on availability of the latest technology and Germany takes over from the US on innovation capability.
- Norway still has by far the highest market share for EVs, included as most AVs are expected to be electric.

Methodology

The pillar is calculated from nine equally weighted measures, two more than in the 2019 AVRI. It includes two new variables, covering cybersecurity and cloud computing, artificial intelligence and the Internet of Things.

Industry partnerships: the measure is scored out of seven for this index, based on a review of news coverage from local and global media, research from consulting firms and blogs maintained by AV industry experts. The rapid and disruptive nature of AV technology has made partnerships between vehicle makers and technology suppliers essential, and many have been formed recently. Those countries that are home to companies that have established a large number of partnerships are given higher scores. Canada, China, Germany, South Korea and the US all gained the maximum score. Mexico scored the lowest, followed by Brazil and India.

AV technology firm headquarters: based on a list of AV-related technology companies built from those published by Topio Networks[160] and Crunchbase Pro[161] on AV companies, updated with those founded since the previous edition of the AVRI. The US has the highest number of headquarters at 420 followed by Israel with 84 and the UK with 72. Numbers are scaled by national population, with the result that Israel has by far the highest score, while Brazil, Mexico and India are ranked lowest.

AV-related patents: this measure uses data from PatSeer[162] on all AV-related patents and patent applications made by the end of 2019. The highest number of patent applications came from Japan with 8,037, US with 5,995 and Germany with 4,291. Numbers are scaled by national populations, and on this basis Japan remains top, followed by South Korea and Germany. No patents were found for the UAE.

Industry investments in AV: using all AV-related investments listed by Topio Networks and Crunchbase Pro, this measure is based on the countries of investing organizations, rather than where the investment is made. Again, this is scaled by national populations. Israel is by far the leading country for investment on a per capita basis, followed by the US and Germany. Eight countries received the minimum score as no industry investments were found.

Availability of the latest technologies: drawn from the World Economic Forum's *Executive opinion survey* for 2016-17, published in the Portulans Institute's 2019 *Network readiness index*.[163] Those surveyed judged that Finland, followed by Norway and Israel, have the greatest access to the latest technologies while Russia, then China and Brazil, have the lowest.

Innovation capability: this uses the pillar of this name in the World Economic Forum's *Global competitiveness index* for 2019, as judged by business executives in each country. They rated Germany top, followed by the US and Taiwan, with Chile, Mexico and Hungary bottom.

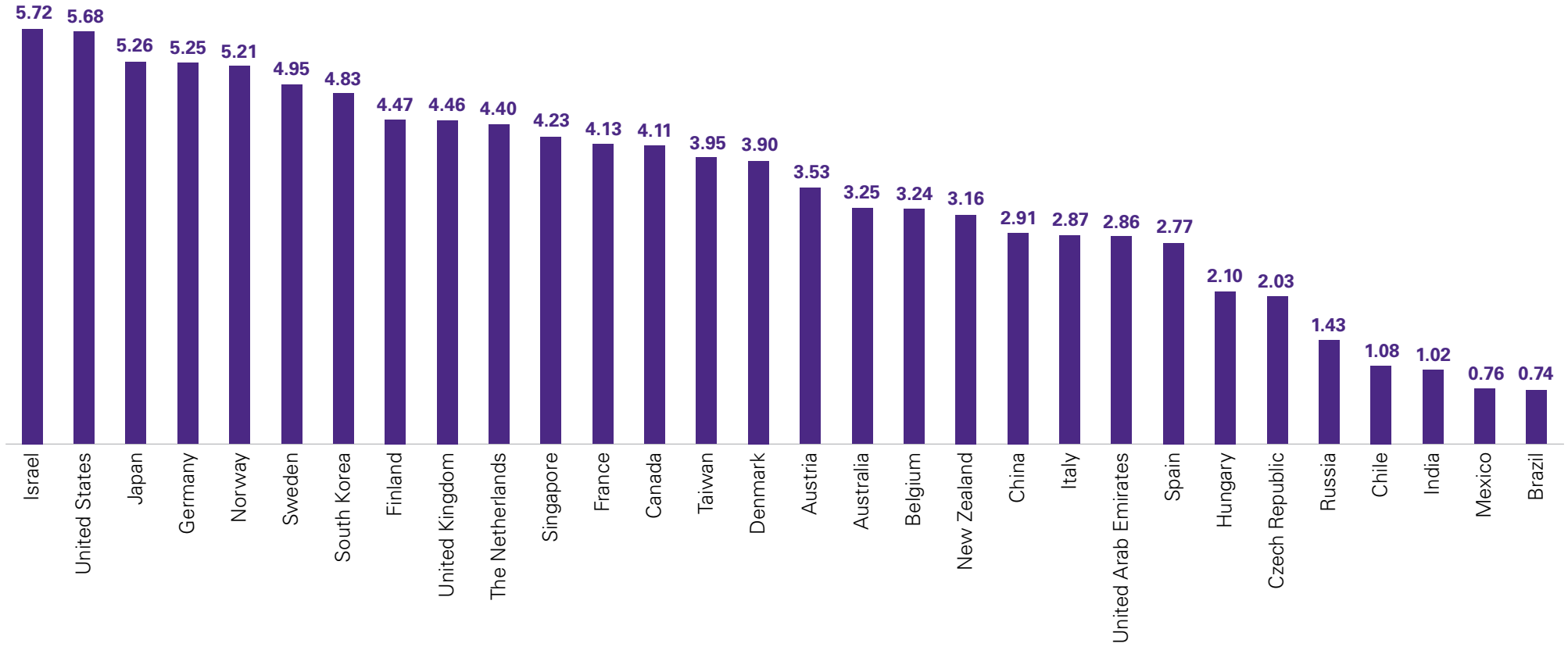
Cybersecurity: a new measure for this edition of the AVRI drawn from the International Telecoms Union's *Global cybersecurity index*, published in 2018.[164] The ratings, based on a survey of ITU members, put the UK first followed by the US and France. Chile received the lowest rating, followed by the Czech Republic and Brazil.

Assessment of cloud computing, artificial intelligence and Internet of Things: this new measure is drawn from the average of three of four 'technology enabler' indicators within the 2019 *Global connectivity index* published by Chinese telecoms company Huawei.[165] The index does not include data for Israel or Taiwan, so these countries use scores

based on those for the two countries immediately above and below them in the World Economic Forum's innovation capability rating. Israel's score is the average of Austria, Belgium, Canada and Singapore and Taiwan's is the average of Germany, South Korea, Sweden and the US. The highest score went to the US, followed by Sweden and Denmark, while the lowest scores went to India, Russia and Hungary.

Market share of electric cars: this measure uses data from EV-Volumes.com,[166] a Swedish data and consultancy firm, on the 2019 market share of passenger vehicles that work entirely from batteries or are plug-in hybrids. Countries are scored based on the size of EV market share, given that most AVs will be electric. No data was available for Singapore and the UAE, for which the average of the other 28 countries and jurisdictions was used. Norway ranked highest, with 56 percent of passenger vehicles in 2019 being battery or plug-in hybrids, followed by the Netherlands with 15 percent and Sweden with 11 percent. India had the lowest market share, followed by Brazil and Russia.

Pillar 2 scores: Technology and innovation



Technology and innovation pillar scores breakdown by variable

	Position	Industry partnerships	AV technology firm headquarters	AV-related patents	Industry investments in AV	Availability of the latest technologies	Innovation capability	Cybersecurity	Assessment of cloud computing, AI and IoT	Market share of electric cars	Pillar 2 score (unadjusted)
1	**Israel**	0.750	1.000	0.052	1.000	0.946	0.716	0.679	0.551	0.029	**5.722**
2	**United States**	1.000	0.122	0.298	0.370	0.931	0.939	0.989	1.000	0.033	**5.681**
3	**Japan**	0.917	0.022	1.000	0.055	0.843	0.808	0.889	0.707	0.017	**5.258**
4	**Germany**	1.000	0.078	0.849	0.124	0.751	1.000	0.822	0.574	0.052	**5.250**
5	**Norway**	0.917	0.053	0.012	0.000	0.971	0.576	0.915	0.764	1.000	**5.209**
6	**Sweden**	0.833	0.203	0.352	0.051	0.937	0.826	0.737	0.805	0.201	**4.946**
7	**South Korea**	1.000	0.026	0.856	0.023	0.633	0.826	0.874	0.551	0.043	**4.832**
8	**Finland**	0.833	0.171	0.017	0.035	1.000	0.752	0.837	0.705	0.123	**4.475**
9	**United Kingdom**	0.833	0.104	0.113	0.011	0.855	0.806	1.000	0.676	0.057	**4.456**
10	**The Netherlands**	0.667	0.066	0.032	0.103	0.907	0.763	0.900	0.701	0.265	**4.403**
11	**Singapore**	0.833	0.133	0.020	0.004	0.771	0.738	0.928	0.717	0.085	**4.230**
12	**France**	0.833	0.043	0.116	0.029	0.735	0.783	0.972	0.567	0.049	**4.127**
13	**Canada**	1.000	0.085	0.012	0.073	0.782	0.711	0.915	0.488	0.047	**4.114**
14	**Taiwan**	0.833	0.007	0.094	0.000	0.551	0.851	0.856	0.736	0.018	**3.946**
15	**Denmark**	0.667	0.015	0.011	0.000	0.740	0.761	0.829	0.800	0.074	**3.896**
16	**Austria**	0.667	0.087	0.036	0.044	0.685	0.722	0.772	0.450	0.065	**3.527**
17	**Australia**	0.500	0.034	0.045	0.007	0.576	0.609	0.911	0.545	0.020	**3.248**
18	**Belgium**	0.417	0.032	0.007	0.001	0.808	0.652	0.746	0.521	0.057	**3.242**
19	**New Zealand**	0.667	0.019	0.010	0.000	0.743	0.409	0.692	0.567	0.048	**3.155**
20	**China**	1.000	0.002	0.045	0.014	0.023	0.503	0.777	0.446	0.103	**2.913**
21	**Italy**	0.833	0.008	0.012	0.000	0.330	0.519	0.796	0.360	0.016	**2.875**
22	**United Arab Emirates**	0.833	0.008	0.000	0.005	0.787	0.221	0.731	0.193	0.085	**2.864**
23	**Spain**	0.500	0.015	0.013	0.000	0.462	0.492	0.924	0.338	0.025	**2.769**
24	**Hungary**	0.667	0.037	0.006	0.026	0.371	0.111	0.742	0.103	0.033	**2.095**
25	**Czech Republic**	0.583	0.007	0.008	0.000	0.543	0.325	0.215	0.335	0.009	**2.025**
26	**Russia**	0.333	0.004	0.007	0.001	0.000	0.235	0.794	0.058	0.001	**1.432**
27	**Chile**	0.333	0.004	0.001	0.000	0.554	0.000	0.000	0.190	0.001	**1.084**
28	**India**	0.167	0.001	0.001	0.000	0.122	0.190	0.540	0.000	0.000	**1.020**
29	**Mexico**	0.000	0.000	0.001	0.000	0.269	0.025	0.345	0.122	0.001	**0.763**
30	**Brazil**	0.167	0.001	0.001	0.000	0.046	0.144	0.232	0.144	0.001	**0.736**

Infrastructure

Overview

- The Netherlands continues to be the clear leader of the infrastructure pillar, as a result of leading the measure of EV charging stations (now scaled by population rather than road network), running a close second to Singapore on road quality and performing strongly on other measures.
- South Korea, which is second on the pillar overall continues to lead on the measure of 4G coverage. As in the 2019 AVRI the UAE leads on the change readiness of its technology infrastructure.
- Singapore and Australia share the top rating for broadband and the UAE has the best result for mobile connection speeds, with the last two measures given half the weight of others. These are included given the importance of digital infrastructure to AV development.

Methodology

The pillar is calculated from six measures, one fewer than in the 2019 index. However, those on mobile connecting speed and broadband have half the weight of the other four measures.

EV charging stations: data for 18 countries comes from the International Energy Agency's *Global EV outlook 2019*[167] while information for other countries is gathered from the European Alternative Fuels Observatory[168] and country-specific data sources. Numbers of chargers are scaled by population (changed from road length as in previous editions). As most AVs are likely to be EVs, their adoption will require the availability of electric charging stations, so countries with more charging stations per person score more. The highest-scoring countries are the Netherlands, which has three charging stations per thousand residents, followed by Norway with 2.4; no other country has more than one per thousand. Brazil, India and Russia have the fewest stations.

4G coverage: based on data from researcher OpenSignal published in May 2019, this measure is included to reflect the importance to AVs of wide access to mobile data networks.[169] No data was available for Taiwan, which receives the average mark for the other 29 countries. South Korea has the most extensive 4G coverage of the countries in the research, followed by Japan and Norway, while Israel has the least, followed by Brazil and Russia.

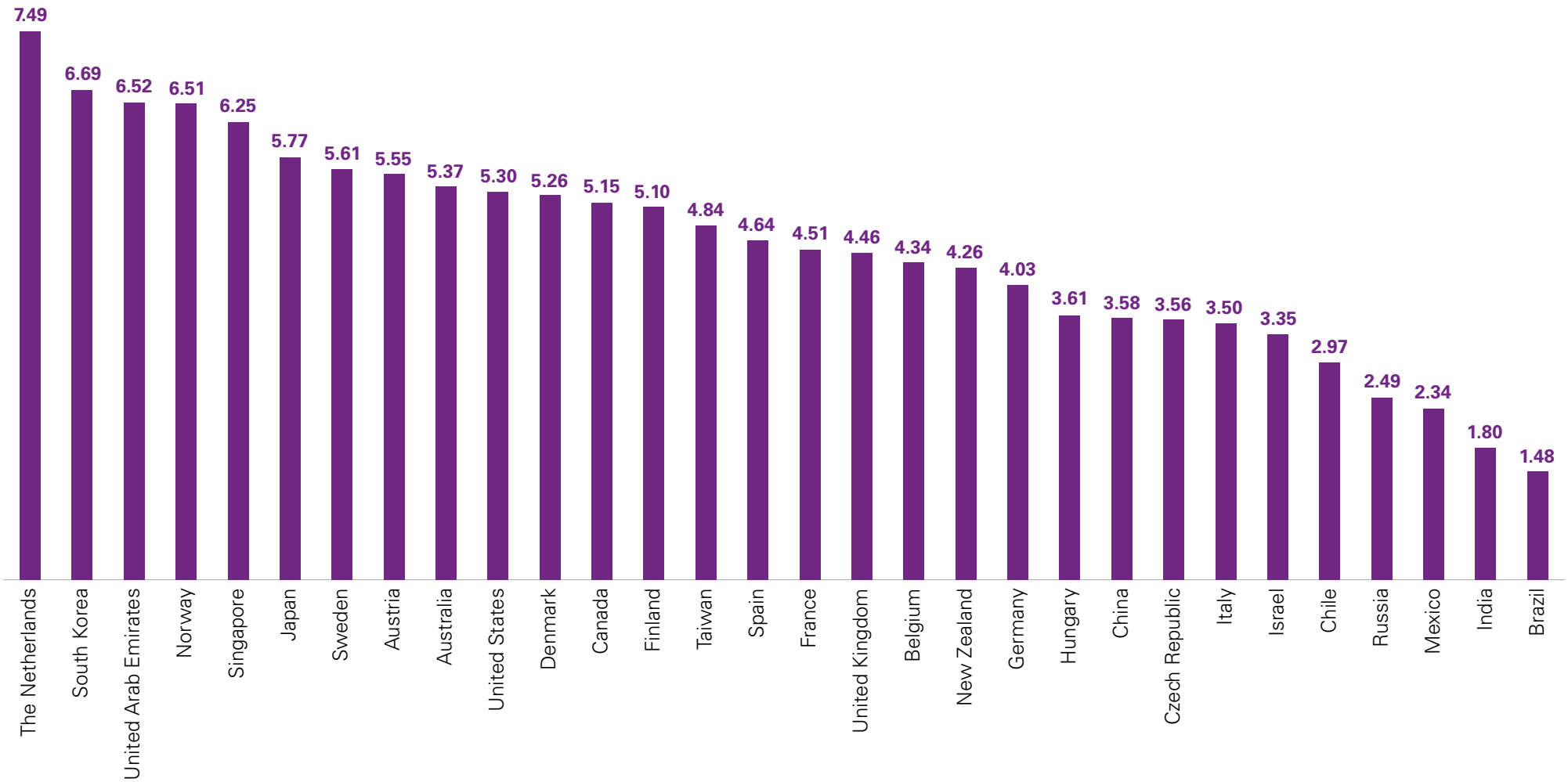
Quality of roads: from the World Economic Forum's *Global competiveness report*, assessed by business executives in each country.[170] AVs will work better on high-quality roads, with poor highways limiting a country's adoption. Singapore has the best roads on this measure, followed by the Netherlands and Japan, while Brazil, Russia and the Czech Republic have the worst.

Technology infrastructure change readiness: scores are based on KPMG International's 2019 *Change readiness index*.[171] This measures the quality of national technology infrastructure, using a number of indicators to provide an additional measure of the technology infrastructure that will help support the use of AVs. No data was published for Taiwan, which received the average mark for the other 29 countries. The UAE led this measure, followed by Austria and Singapore, with India, Mexico and China scoring least.

Mobile connection speed: this new measure draws on mobile connection speed data published by US network testing company Ookla as part of its Speedtest service for March 2020.[172] The UAE, followed by South Korea and Canada, have the fastest mobile internet services on this measure while India, Chile and Russia have the slowest. This measure is given a half weighting, along with broadband.

Broadband: this measure, new to this edition, uses the broadband technology enabler indicator from the 2019 *Global connectivity index* published by Chinese telecoms company Huawei.[173] The index does not include data for Israel or Taiwan, so these countries use scores based on those for the two countries immediately above and below them in the World Economic Forum's innovation capability rating (see technology methodology). Israel's score is the average of Austria, Belgium, Canada and Singapore and Taiwan's is the average of Germany, South Korea, Sweden and the US. The highest score went to Australia and Singapore, while the lowest score went to India, followed by China and Mexico. This measure is given a half weighting, along with mobile connection speed.

Pillar 3 scores: Infrastructure



Infrastructure pillar scores breakdown by variable

	Position	EV charging stations	4G coverage	Quality of roads	Technology infrastructure change readiness	Mobile connection speed (0.5 weight)	Broadband (0.5 weight)	Pillar 3 score (unadjusted)
1	**The Netherlands**	1.000	0.832	0.993	0.622	0.755	0.792	**4.221**
2	**South Korea**	0.060	1.000	0.838	0.689	0.959	0.917	**3.525**
3	**Norway**	0.808	0.929	0.448	0.467	0.728	0.958	**3.495**
4	**United Arab Emirates**	0.010	0.636	0.869	1.000	1.000	0.833	**3.431**
5	**Singapore**	0.095	0.739	1.000	0.756	0.578	1.000	**3.379**
6	**Japan**	0.078	0.957	0.894	0.689	0.272	0.958	**3.233**
7	**Austria**	0.166	0.611	0.871	0.844	0.498	0.708	**3.095**
8	**Sweden**	0.290	0.771	0.669	0.578	0.473	0.958	**3.023**
9	**United States**	0.070	0.839	0.714	0.600	0.393	0.917	**2.878**
10	**Denmark**	0.158	0.682	0.744	0.556	0.491	0.875	**2.823**
11	**Finland**	0.068	0.714	0.653	0.644	0.483	0.833	**2.738**
12	**Australia**	0.010	0.743	0.557	0.578	0.693	1.000	**2.735**
13	**Canada**	0.074	0.689	0.587	0.378	0.788	0.917	**2.580**
14	**Taiwan**	0.024	0.588	0.754	0.533	0.453	0.865	**2.558**
15	**Spain**	0.062	0.639	0.782	0.533	0.327	0.750	**2.555**
16	**United Kingdom**	0.141	0.543	0.538	0.689	0.313	0.750	**2.442**
17	**France**	0.150	0.364	0.704	0.533	0.467	0.792	**2.381**
18	**Belgium**	0.192	0.746	0.399	0.333	0.516	0.708	**2.283**
19	**Germany**	0.165	0.264	0.666	0.600	0.328	0.667	**2.192**
20	**New Zealand**	0.021	0.250	0.420	0.711	0.522	0.917	**2.121**
21	**Hungary**	0.023	0.782	0.293	0.333	0.433	0.542	**1.919**
22	**China**	0.079	0.581	0.456	0.267	0.751	0.250	**1.884**
23	**Italy**	0.024	0.339	0.406	0.622	0.318	0.625	**1.863**
24	**Czech Republic**	0.033	0.754	0.261	0.289	0.496	0.542	**1.856**
25	**Israel**	0.108	0.000	0.537	0.578	0.146	0.833	**1.712**
26	**Chile**	0.002	0.257	0.638	0.422	0.117	0.542	**1.648**
27	**Russia**	0.001	0.157	0.136	0.622	0.117	0.625	**1.287**
28	**Mexico**	0.007	0.368	0.434	0.200	0.218	0.333	**1.284**
29	**India**	0.000	0.764	0.437	0.000	0.000	0.000	**1.202**
30	**Brazil**	0.001	0.089	0.000	0.311	0.171	0.417	**0.695**

Consumer acceptance

Overview

- Singapore leads this pillar as it has in both the previous editions of the AVRI, due to all of the city-state's population living near an AV test area and strong performance on most other measures.
- Finland, which moves from fifth to second on consumer acceptance overall, leads on market penetration of ride-hailing and on a measure of the population's digital skills.
- South Korea leads on ICT adoption and the UAE leads on a measure of individual readiness.

Methodology

The pillar is calculated from six equally weighted measures, one more than in 2019. A survey-based measure used in the previous edition has been dropped, but two new measures of digital skills and individual readiness have been added.

Population living near test areas: this measure uses data on cities carrying out AV testing collected by Bloomberg Philanthropies and Aspen Institute.[174] The proportion of national populations living in test areas is then calculated based on city populations from the McKinsey Global Institute's Urban World app.[175] The more people see AVs on the road, the more comfortable that they are likely to use them when they become available, so countries with a higher proportion of population that live in cities where AV pilots and testing are underway scored the highest. The countries with the highest proportions are Singapore, the Netherlands and Denmark. There are currently no AV testing areas in nine of the countries in the index.

Civil society technology use: scores are based on the people and civil society technology use sub-indicator of KPMG International's 2019 *Change readiness index*.[176] This is included as the use of other types of consumer technology indicates the potential for consumers to embrace AVs. The leading countries are Sweden, the US and Finland while the lowest-scoring are Brazil, Mexico and Hungary.

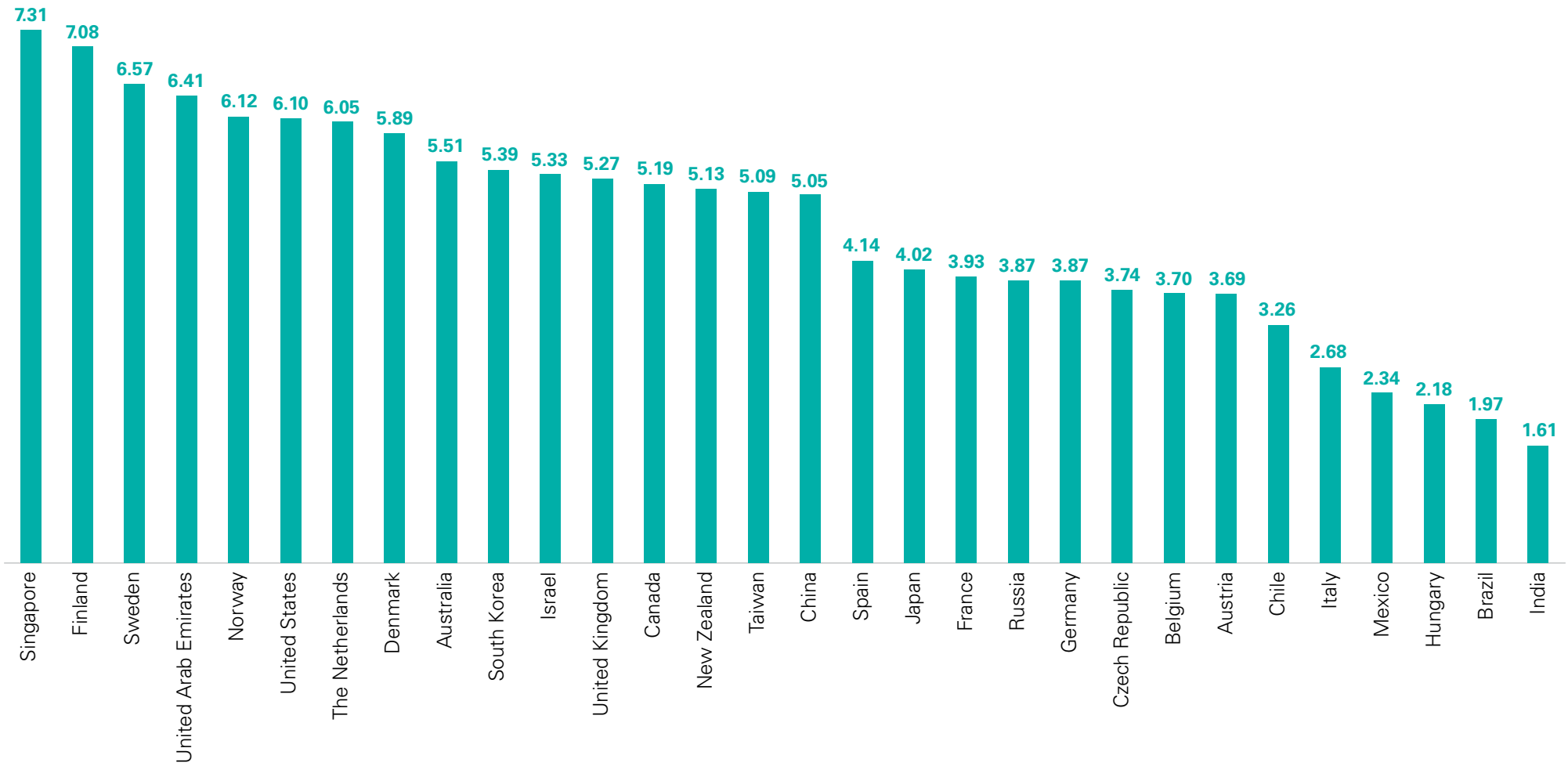
Consumer ICT adoption and **digital skills:** both drawn from using the World Economic Forum's *Global competiveness report*.[177] ICT adoption includes mobile telephone and broadband subscriptions, broadband and fiber internet subscriptions and overall internet users. The measure is led by South Korea, the UAE and Sweden, with India last followed by Mexico and Brazil.

The measure of digital skills among the active population, a new addition for this edition, comes from a survey of executives carried out by the forum. This was led by Finland, Sweden and the Netherlands, with Brazil receiving the lowest score, followed by Mexico and Hungary.

Individual readiness: a new measure based on the individuals sub-pillar of the Portulans Institute's 2019 *Network readiness index*.[178] This uses data from the International Telecommunication Union on internet users and mobile broadband subscriptions, We are Social and Hootsuite on active social media users and Unesco on tertiary education enrollment, adult literacy rate and the proportion of youth and adults with ICT skills, all for 2018. This put the UAE first, followed by Taiwan and Denmark, with India last followed by Hungary and Brazil.

Online ride-hailing market penetration: using data from German researcher Statista on the percentage of people in each country who have used a ride-hailing service, based on nationally representative surveys in each country.[179] These found that people in Finland, China and Singapore are most likely to have used such a service, while those in Italy and Japan are least likely to have done so.

Pillar 4 scores: Consumer acceptance



Consumer acceptance pillar scores breakdown by variable

	Position	Population living near test areas	Civil society technology use	Consumer ICT adoption	Digital skills	Individual readiness	Online ride-hailing market penetration	Pillar 4 score (unadjusted)
1	**Singapore**	1.000	0.514	0.906	0.910	0.715	0.828	**4.873**
2	**Finland**	0.364	0.886	0.796	1.000	0.673	1.000	**4.718**
3	**Sweden**	0.353	1.000	0.918	0.941	0.641	0.524	**4.377**
4	**United Arab Emirates**	0.210	0.543	0.985	0.814	1.000	0.719	**4.271**
5	**Norway**	0.342	0.857	0.840	0.805	0.705	0.528	**4.078**
6	**United States**	0.324	0.914	0.695	0.818	0.636	0.682	**4.069**
7	**The Netherlands**	0.811	0.814	0.728	0.926	0.624	0.131	**4.034**
8	**Denmark**	0.574	0.729	0.843	0.849	0.734	0.199	**3.927**
9	**Australia**	0.365	0.786	0.684	0.705	0.719	0.412	**3.670**
10	**South Korea**	0.216	0.514	1.000	0.694	0.690	0.483	**3.597**
11	**Israel**	0.562	0.643	0.585	0.880	0.472	0.412	**3.553**
12	**United Kingdom**	0.305	0.714	0.674	0.674	0.541	0.607	**3.515**
13	**Canada**	0.477	0.729	0.629	0.724	0.444	0.453	**3.457**
14	**New Zealand**	0.342	0.757	0.751	0.672	0.583	0.315	**3.420**
15	**Taiwan**	0.465	0.171	0.827	0.748	0.749	0.435	**3.396**
16	**China**	0.043	0.571	0.764	0.573	0.419	0.993	**3.364**
17	**Spain**	0.000	0.329	0.759	0.457	0.676	0.539	**2.761**
18	**Japan**	0.302	0.286	0.891	0.490	0.709	0.000	**2.678**
19	**France**	0.284	0.386	0.685	0.512	0.407	0.348	**2.622**
20	**Russia**	0.000	0.329	0.740	0.678	0.394	0.442	**2.583**
21	**Germany**	0.096	0.529	0.624	0.722	0.483	0.127	**2.581**
22	**Czech Republic**	0.000	0.500	0.598	0.617	0.364	0.416	**2.494**
23	**Belgium**	0.000	0.657	0.575	0.635	0.485	0.116	**2.468**
24	**Austria**	0.000	0.457	0.552	0.617	0.504	0.333	**2.463**
25	**Chile**	0.000	0.257	0.511	0.429	0.612	0.367	**2.176**
26	**Italy**	0.125	0.271	0.534	0.396	0.464	0.000	**1.790**
27	**Mexico**	0.000	0.100	0.377	0.245	0.375	0.464	**1.561**
28	**Hungary**	0.000	0.114	0.529	0.322	0.221	0.266	**1.451**
29	**Brazil**	0.104	0.000	0.428	0.000	0.306	0.476	**1.314**
30	**India**	0.000	0.157	0.000	0.490	0.000	0.427	**1.074**

Endnotes

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10 Johannes Stalzer, 'Austria paves the legal way for (partly) autonomous vehicles', Schoenherr, 21 March 2019

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This report was first published as Building Trust Through Tax Technology in Australia by Mathew Herring, Partner, National Head of Technology & Innovation Deals, Tax & Legal, KPMG Australia and Renuka Kimber, Senior Manager, Technology & Innovation Deals, Tax & Legal, KPMG Australia. In its current form, this publication has been expanded upon to provide a global context and bring insights to audiences around the world. Please note that KPMG Australia is a limited liability partnership and one of the global network of independent member firms affiliated with KPMG International Cooperative ("KPMG International").

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Designed by Evalueserve.

Publication name: 2020 Autonomous Vehicles Readiness Index

Publication number: 136956-G

Publication date: July 2020