KPMG

Autonomous Vehicles Readiness Index

Assessing countries' openness and preparedness for autonomous vehicles

KPMG International

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Foreword

The world is on the cusp of a transport revolution. Technology is transforming the industry, and the pace of innovation is accelerating.

It will affect us all. It will not only change the way we travel, but the way we live. It will change the way we spend our time at leisure, and at work. It will change the way businesses import materials, distribute their products, and employ staff.

Electric vehicles, mobility on demand, digital railways, drone deliveries and ultra-high speed trains are just some of the components of that revolution. But it is autonomous technology that will really transform our lives, because it will mean for the first time in history, mobility freedom will be available for everyone, everywhere.

Over the last couple of years, I have traveled extensively talking to governments, city authorities and businesses about the opportunity created by autonomous vehicles (AVs). While most believe it will be many years before fully autonomous travel is available to all, nearly everyone I have spoken with recognizes that the potential benefits of the autonomous revolution are enormous.

There will be economic benefits, because the time we currently spend driving a car becomes productive time in an AV that can be spent working, relaxing or sleeping. But moreover, there will be social benefit, including a vast reduction in the 1.3 million people killed each year in car accidents,[1] and accessibility for those who currently cannot drive, because of age or disability.

But there are challenges too. Will AVs increase congestion? How can we limit the risks of criminal use? What public transport systems will we need in the future?

The size of the global opportunity, and the realization that all over the world authorities were grappling with the same questions, became the inspiration for this *Autonomous Vehicles Readiness Index* (AVRI). If we could start to show what different countries were doing to prepare for the future, we could spread best practice and open up dialogue.

I hope in a small way this index may serve to accelerate the pace of change for the benefit of society everywhere.

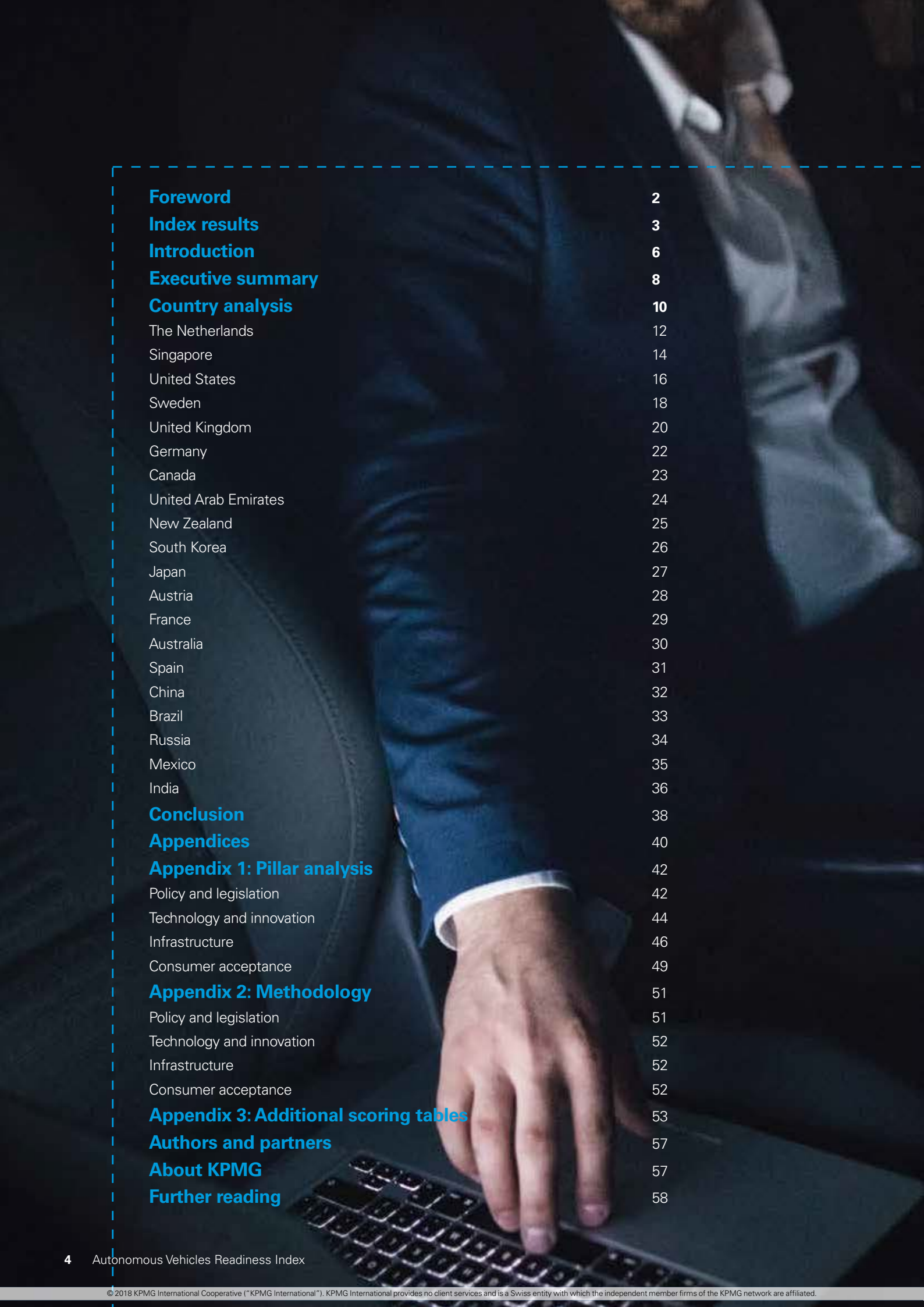
Richard Threlfall

Global Head of Infrastructure
KPMG International
@RThrelfall_KPMG

1. http://asirt.org/initiatives/informing-road-users/road-safety-facts/road-crash-statistic

Index results

Overall rank	Country	Total score	Policy and legislation		Technology & innovation		Infrastructure		Consumer acceptance	
			Rank	Score	Rank	Score	Rank	Score	Rank	Score
1	The Netherlands	27.73	3	7.89	4	5.46	1	7.89	2	6.49
2	Singapore	26.08	1	8.49	8	4.26	2	6.72	1	6.63
3	United States	24.75	10	6.38	1	6.97	7	5.84	4	5.56
4	Sweden	24.73	8	6.83	2	6.44	6	6.04	6	5.41
5	United Kingdom	23.99	4	7.55	5	5.28	10	5.31	3	5.84
6	Germany	22.74	5	7.33	3	6.15	12	5.17	12	4.09
7	Canada	22.61	7	7.12	6	4.97	11	5.22	7	5.30
8	United Arab Emirates	20.89	6	7.26	14	2.71	5	6.12	8	4.79
9	New Zealand	20.75	2	7.92	12	3.26	16	4.14	5	5.43
10	South Korea	20.71	14	5.78	9	4.24	4	6.32	11	4.38
11	Japan	20.28	12	5.93	7	4.79	3	6.55	16	3.01
12	Austria	20.00	9	6.73	11	3.69	8	5.66	13	3.91
13	France	19.44	13	5.92	10	4.03	13	4.94	10	4.55
14	Australia	19.40	11	6.01	13	3.18	9	5.43	9	4.78
15	Spain	14.58	15	4.95	16	2.21	14	4.69	17	2.72
16	China	13.94	16	4.38	15	2.25	15	4.18	15	3.13
17	Brazil	7.17	20	0.93	18	0.86	19	1.89	14	3.49
18	Russia	7.09	17	2.58	20	0.52	20	1.64	18	2.35
19	Mexico	6.51	19	1.16	17	1.01	17	2.34	19	2.00
20	India	6.14	18	1.41	19	0.54	18	2.28	20	1.91



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Introduction: Why policymakers need to focus today on autonomous vehicles

The pace of development of AVs is breathtaking. A year ago, some would have argued that they would never become a reality. But now, AVs are being piloted in a number of countries and are running on public roads, albeit only in a handful of locations such as Phoenix in the US State of Arizona and in Singapore. The question is no longer whether but when all road vehicles become fully autonomous. And whether you believe that will take 10 years or 30, the implications are so far-reaching that policymakers need to start planning now for our AV future.

Economic and social benefits

We believe there will be rapid development and adoption of AVs, because of the alignment of interest of private developers and public authorities.

Companies including the dominant vehicle makers, technology giants and specialist startups have invested US$50 billion over the last 5 years to develop AV technology, with 70 percent of the spending coming from outside the automotive sector.[2]

At the same time, public authorities can see that AVs offer huge potential economic and social benefits. AVs could eliminate the 90–95 percent of road accidents caused by human error,[3] saving as many as a million lives every year. Assuming they are electric, they should also reduce road pollution, improving citizens' health.[4] AVs offer mobility benefits to people who are unable to drive at present, including the elderly, those who do not own a car and those who live in rural areas that do not have adequate public transport. And the hours spent driving which now become productive creates a potentially gigantic economic boost, with one study estimating that the US economy could see an uplift of US$1.3 trillion a year.[5]

For these reasons and others, many governments are keen to move towards an AV future as soon as possible.

Planning now for the long term

But why act now rather than wait to see how quickly AVs are adopted? A key reason for policymakers to consider AVs now is because the spatial planning and infrastructure investment decisions that we make today will determine the development of our countries and cities for decades. If we anticipate an AV future today, we can avoid wasting taxpayers' money on investments that may soon prove obsolete, or worse frustrate the realization of AV benefits.

2. https://www.channelnewsasia.com/news/business/self-driving-startups-race-down-a-narrowing-road-9349722
3. http://channel.staging.alertdriving.com/home/fleet-alert-magazine/international/human-error-accounts-90-road-accidents
4. Driverless cars needed to reduce greenhouse gas emissions
5. http://www.businessinsider.com/morgan-stanley-autonomous-cars-trillion-dollars-2014-9

AVs imply changes to road infrastructure, including on-road telematics, signage, crash barriers, lane widths and curbs. They may also affect business cases for public transport schemes, which will need to integrate with AVs, as well as parking schemes and multimodal transport ticketing.

AVs will also affect the placement and development of homes and businesses. They could make ride-sharing and mobility as a service schemes more attractive, meaning space currently used for parking can give way to more housing and public spaces in urban areas. But by making longer commutes more attractive, they could also encourage more suburban and rural development.[6]

Plugging the job and revenue gaps

AVs will also have major impacts on public policy outside of transport. For example, many professional drivers are at risk of being replaced by technology. KPMG is supporting a study by a student at Harvard's Kennedy School on potential job losses, for example in the trucking and taxi markets and opportunities for new employment in the automotive and supply chain industries.

There are also implications for government revenues. At present, taxes on fossil fuels generate billions of dollars,[7] while electric vehicles receive subsidies in many countries. This means a shift to electric AVs would create a hole in tax revenues. Authorities need to think through urgently how to recover that lost revenue. For example, through road pricing, which might also help tackle congestion.

Enabling AVs

Supporting an AV future implies myriad other public policy enablers too. Authorities will want to ensure that AVs are safe, both mechanically and in terms of their security from cyber-attack, so vehicle licensing could change, with new controls on data security.[8] Regulations on vehicle insurance will need to adapt, including who is responsible for a driverless vehicle's actions. Driving licenses could become redundant, although many countries use them as an identity card. Road traffic regulations, designed for use by humans, will ultimately be replaced by protocols, determining priority at junctions and giving way to emergency vehicles.

The data generated by AVs will present particular policy challenges. Questions include the ownership of this data, whether the security of information is a public or private responsibility and what the data can be exploited for, whether that be advertising, road condition monitoring or passenger health.[9]

Different countries may come to different conclusions across these issues. Indeed the optimal AV future of one city may differ from another nearby, depending on patterns of travel and availability of public transport alternatives. But basic standards of interoperability will need to be put in place across countries and potentially entire continents.

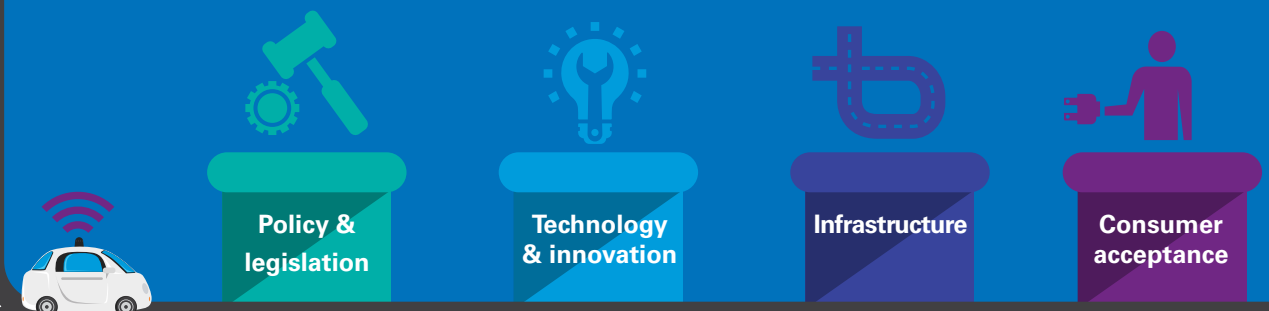
The reality is, AVs will have far-reaching implications across numerous areas of policy-making for countries around the world. So now is the time to plan.

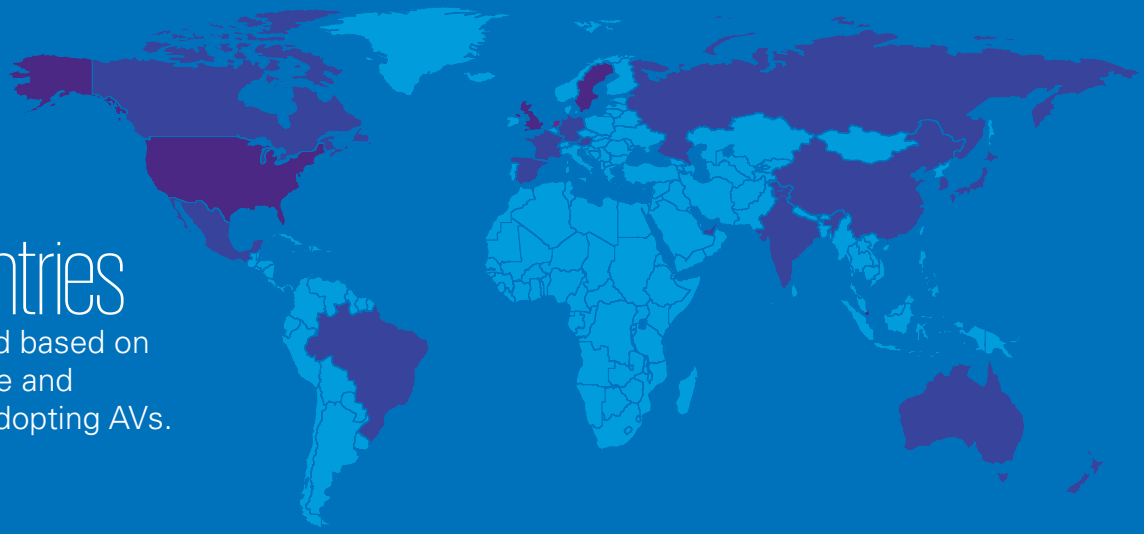
6. http://www.wsp-pb.com/Globaln/UK/WSPPB-Farrells-AV-whitepaper.pdf
7. http://www.taxpolicycenter.org/statistics/motor-fuel-tax-revenue
8. https://home.kpmg.com/xx/en/home/insights/2016/06/autonomous-vehicles-the-public-policy-imperatives.html
9. Ibid.

Executive summary

The AVRI is intended to provide an understanding of various countries' preparedness and openness to AV technology. We hope it will assist public authorities, whether at federal, regional or city level, to learn from others and speed up adoption, which has the potential to offer many benefits to society.

The AVRI consists of 4 pillars

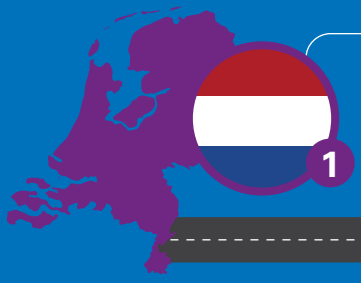




20 countries

were included based on economic size and progress in adopting AVs.

Top ranked country



The Netherlands:

Ranked within the top 4 of each of the four pillars and #1 on infrastructure

Followed closely by

Singapore:
Ranked #1 in policy & legislation and consumer acceptance

US:
Ranked #1 in technology & innovation with strong industry partnerships

Sweden:
Ranked #2 in technology & innovation with the highest number of AV company headquarters by population

UK:
Ranked in the top five for three pillars with strong performance in consumer acceptance and policy & legislation

The bottom 4 countries

India (20th)

Mexico (19th)

Russia (18th)

Brazil (17th)

... are some distance behind the others, indicating they may be slower to adopt AVs and reap the economic and societal benefits.

Conditions for success

Although there is a **high correlation** between **the index rankings** and overall **economic development,** the most prepared countries for AVs all have:

Governments willing to regulate and support AV development

Excellent road and mobile network infrastructure

Private-sector investment and innovation

Large-scale testing powered by a strong automotive industry presence

A proactive government that attracts partnerships with manufacturers

Country analysis

Policy & legislation

Technology & innovation

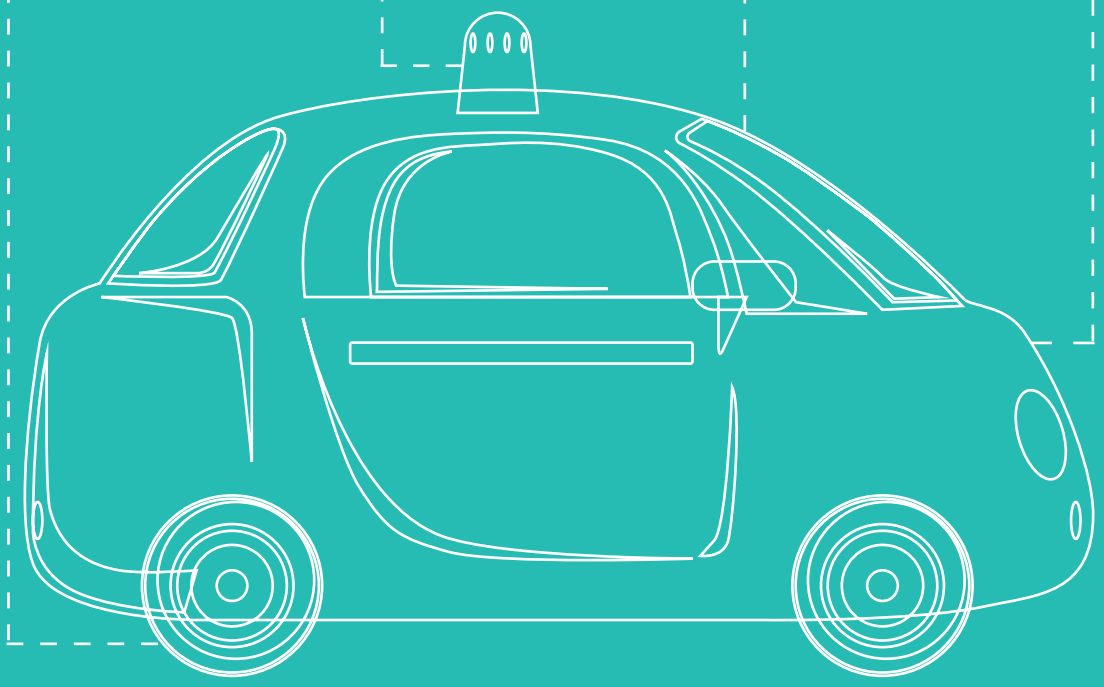
Infrastructure

Consumer acceptance

1 The Netherlands

3rd	4th	1st	2nd

Key takeaways: The Netherlands provides an AV readiness model for other countries to follow, with excellent road infrastructure, a highly supportive government and enthusiastic adoption of electric vehicles.



The Netherlands is the clear leader in this first *Autonomous Vehicles Readiness Index*. It is within the top four of each of the four pillars and ranked number one on infrastructure, most likely due to its heavily-used, well-maintained road network, rated as being among the world's best by the World Economic Forum and the World Bank. It also has by far the highest density of electrical vehicle charging points, with 26,789 publicly-available points in 2016 according to the International Energy Agency's Global EV Outlook — more than Japan has for a road network more than eight times the length. The Netherlands also has high-quality wireless networks too.

As well as having great infrastructure, the country comes second only to Singapore in the consumer acceptance pillar of this research. The Netherlands is the highest of the 20 in the World Economic Forum's technology readiness rating, among the highest in KPMG's assessment of societal change readiness, and three-quarters of the population live in areas that are testing AV technology.

However, consumer survey data finds the Dutch are less accepting of AV technology than most other countries. It should be noted that this is also, true of several of the best-developed countries and may reflect citizens relative satisfaction at the existing state of transport.

On policy and legislation, the Netherlands received the maximum score for regulations and government investment in AV infrastructure. Its Council of Ministers approved testing in 2015, and it took the lead in establishing the Declaration of Amsterdam through which EU countries agreed to speed the development of self-driving vehicles. Additionally, in February 2017 the government approved a bill to allow AV trials without a driver.[10] The Dutch government is investing EUR90 million in adjusting more than 1,000 traffic lights across the country to communicate with vehicles,[11] and is backing a plan to establish automated trucks running from Rotterdam to other cities.[12]

On technology and innovation, the country has by far the highest percentage usage of electric vehicles of the 20 countries in this index at present — 6.39 percent in 2016 according to the International Energy Agency, nearly double second-placed Sweden — and has a high number of AV companies based in the country on a population-adjusted basis. Startups such as Amber Mobility are challenging incumbents and are broadening existing beliefs and behaviors. Though scoring relatively poorly on AV-related patents and investments, there has been a recent uptick in public-private partnerships, which are further accelerating the development of automotive expertise and innovation capacity. Strong examples include the Automotive High Tech Campus in the Eindhoven area and the connected TU Eindhoven University, which has a specific smart mobility faculty.

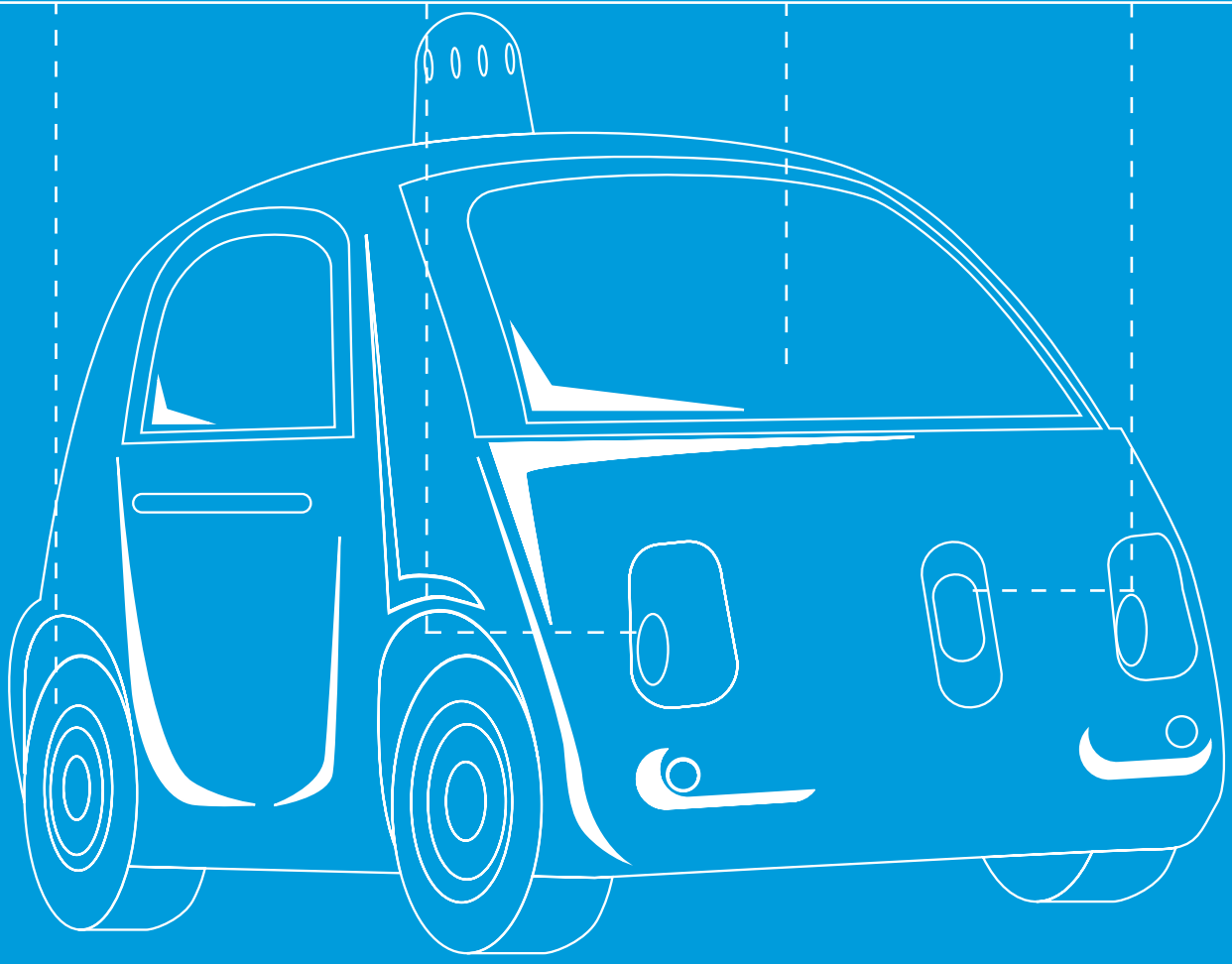
> The Dutch ecosystem for AVs is ready. The intensively-used Dutch roads are very well developed and maintained and other indicators like telecoms infrastructure are also very strong. In addition, the Dutch government Ministry of Infrastructure has opened the public roads to large-scale tests with self-driving passenger cars and lorries.
>
> **— Stijn de Groen,**
> Manager, Digital Advisory
> KPMG in the Netherlands

10. https://www.government.nl/latest/news/2017/02/24/driverless-cars-on-the-roads
11. https://reports.autovistagroup.com/blogs/news/dutch-prepare-for-autonomous-driving
12. https://www.anwb.nl/binaries/content/assets/anwb/pdf/over-anwb/persdienst/rapport_inventarisatie_zelfrijdende_auto.pdf

2 Singapore

1st	8th	2nd	1st

Key takeaways: Singapore's 2017 amendment to its Road Traffic Act allowing self-driving vehicles to be tested on public roads has helped the city state gain its high level of readiness for AVs.



Singapore tops two pillars of this index, policy and legislation and consumer acceptance, and is second only to the Netherlands on infrastructure. On policy and legislation, it receives the maximum score on regulation, with a 2017 amendment to its Road Traffic Act allowing self-driving vehicles to be tested on public roads,[13] and a single entity to coordinate AV work, the Singapore Autonomous Vehicle Initiative announced in 2014.

Singapore's Land Transport Authority (LTA) takes a safety-first approach with AV trials starting on lightly used roads and graduating to more congested environments only after they have demonstrated readiness. All test AVs will be required to log travel data to enable accident investigations and liability claims.

On consumer acceptance, the entire city-state of Singapore is effectively a test area for AVs, meaning all residents may see the technology in development. Consumer research suggests they are more open to the technology than many other countries, including the Netherlands. The country's strong scores for infrastructure, including very high road and mobile network quality, are only undermined by a low density of charging stations for electric vehicles.

Singapore fails to attain the top spot because of its average performance on technology and innovation. It lacks technology company headquarters, patents or investment and has a low use of electric cars. This is compensated for by a significant number of industry partnerships, including MIT spin-out nuTonomy testing driverless taxis there since 2016,[14] the fact that Uber is widely available and a good rating from the World Economic Forum on availability of the latest technology.

> The Land Transport Authority introduced a regulatory framework that minimizes the occurrence of accidents. Operators are required to have a qualified safety driver who will be able to take control of the vehicle in an emergency, hold third-party liability insurance and share data from the trials with the LTA.

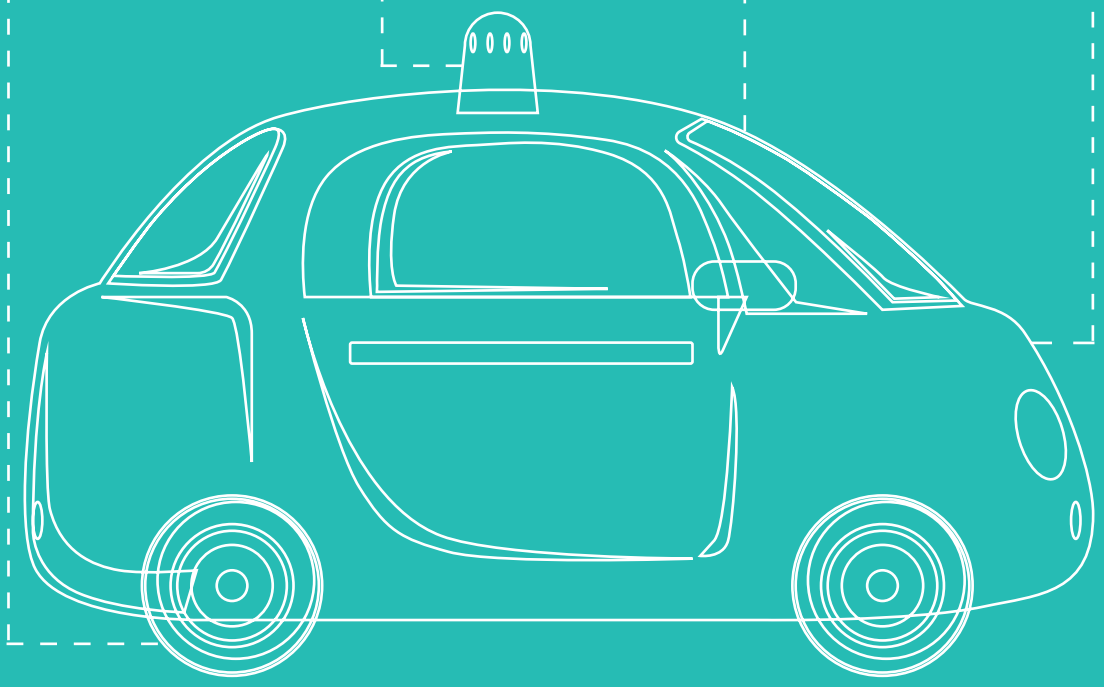
— Satya Ramamurthy
Partner, Head of Government & Infrastructure
KPMG in Singapore

13. https://e27.co/singapores-latest-regulatory-sandbox-concentrate-transportation-20170208/
14. https://www.enterpriseinnovation.net/article/singapore-gears-autonomous-vehicle-technology-1826417780

3 United States

10th	1st	7th	4th

Key takeaways: The US leads the world on AV innovation readiness, including 163 company headquarters. The adoption of national standards would allow this to be better exploited.



The US leads in AV innovation, and is ranked at the top of the technology and innovation pillar of this index. It scores maximum or near-maximum ratings on industry partnerships, research and development hubs, AV technology company headquarters, investment, and World Economic Forum ratings for technology availability and capacity for innovation.

The country has by far the greatest number of AV companies, with 163 headquarters, with second-placed Germany having just 22, although this is adjusted by population for the index.

Companies including the Detroit-based 'Big 3' auto-makers, other automotive companies, ridesharing companies such as Uber and Lyft and intermodal innovators like Hyperloop are all involved in research. So are companies from other countries, with Japan's Toyota basing a US$1 billion research hub in Michigan[15] and using a testing proving ground in California.[16] Despite poor scores on patents and low usage of electric cars, currently 0.92 percent, the US is the clear leader in this area.

While the prospect of AV adoption is generating a great deal of enthusiasm, it is also creating a good deal of confusion. The driving public is generally aware that AVs are being tested at numerous sites across the country, but little is clearly understood with regard to the actual capabilities of early vehicles or the timing for adoption.

The country has a generally good score on consumer acceptance, boosted by strong ratings from KPMG's *Change Readiness Index* and the World Economic Forum, but is undermined by low levels of acceptance of AV technology by consumers and the fact that, despite its 23 test locations being the largest number of any country, only a relatively small proportion of Americans live in them.

On infrastructure, the US has relatively few electric vehicle charging stations given the large size of its road network, and a poorer road quality and infrastructure than either the Netherlands or Singapore, although it does well on 4G network coverage. On policy and legislation, the US gains average scores for specific regulations and government investment in AV, and a low rating from the World Economic Forum for effectiveness of its law-making.

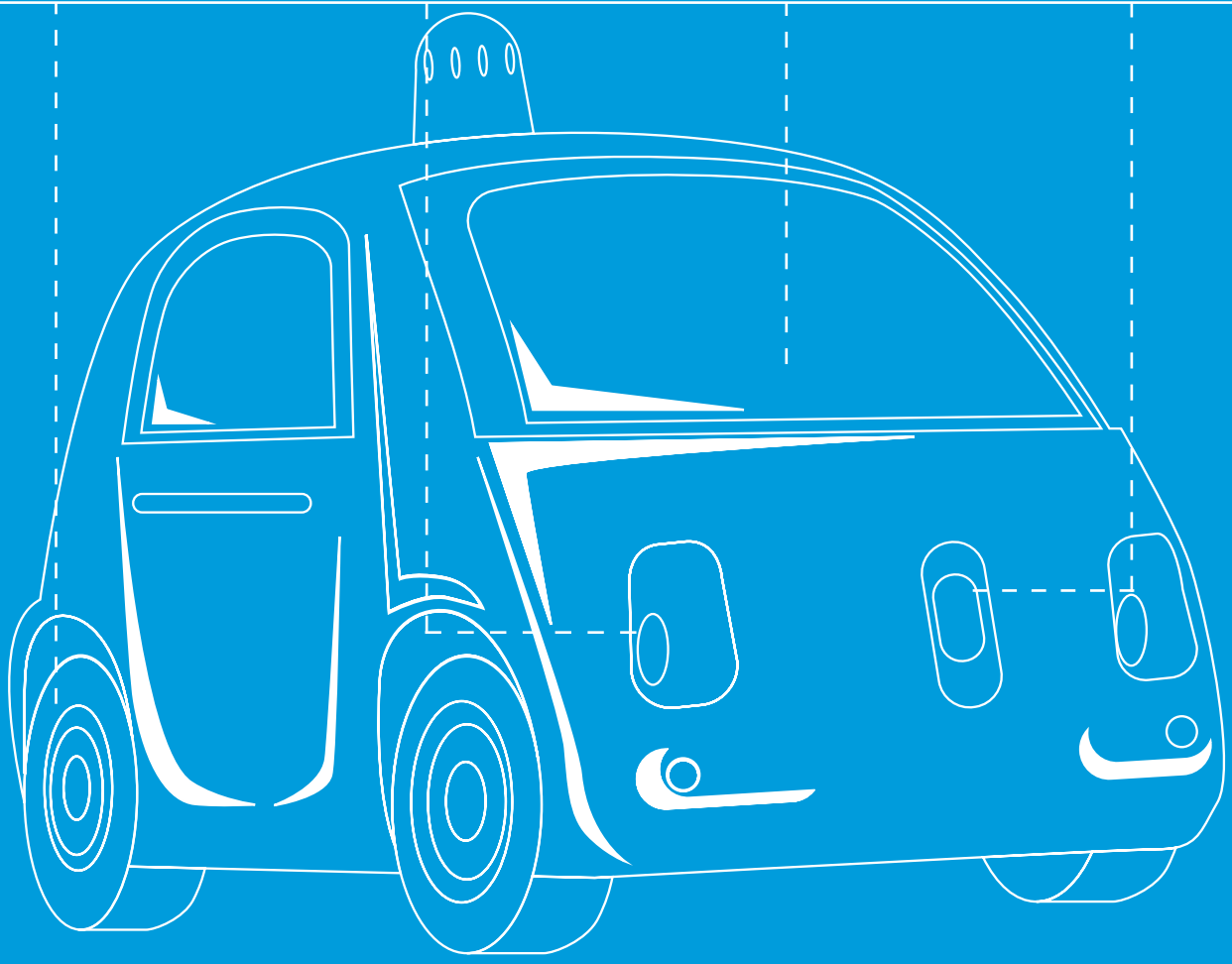
> "The US has a highly innovative but largely disparate environment with little predictability regarding the uniform adoption of national standards for AVs. Therefore the prospect of widespread driverless vehicles is unlikely in the near future. However, federal policy and regulatory guidance could certainly accelerate early adoption, particularly concerning limited freight applications such as truck platooning."
>
> **— Timothy D. Wilschetz**
> Principal, Infrastructure Advisory, KPMG in the US

15. http://www.xconomy.com/detroit-ann-arbor/2016/05/02/toyota-opens-new-1b-autonomous-vehicle-research-hub-in-ann-arbor/
16. http://design.automotive-business-review.com/news/toyota-research-institute-forms-partnership-with-gomentum-to-test-self-driving-technology-5961070

4 Sweden

8th	2nd	6th	6th

Key takeaways: Several initiatives by Volvo support Sweden's strength in AV innovation. Further development of its electric vehicle charging network and more testing would build on this work.



Sweden, which has almost the same overall score as the US, ranks between second and eighth across the pillars in this index. It is strongest in the technology and innovation pillar, where it has the highest number of AV company headquarters by head of population, a strong showing on AV investments (again, adjusted for population) and one of the highest ratings from the World Economic Forum for availability of the latest technology. Swedish-based (although Chinese-owned) vehicle maker Volvo has undertaken several AV initiatives, including a US$300 million joint-venture with Uber; a safety initiative also involving Autoliv and Ericsson; and research giving self-driving cars to real users on a pre-selected route in Gothenburg.[17,18] Sweden also has the second-highest electric car share of the 20 countries, at 3.41 percent. Lower scores on industry partnerships, research and development hubs and patents prevent a higher rank.

On policy and legislation, Sweden has one of the highest government capability scores from KPMG's *Change Readiness Index* research, but lower ratings on AV-specific areas. However, in 2015, the Swedish government initiated a proposal to regulate trials of self-driving vehicles, concluding that it's possible to carry out trials at all levels of automation on Swedish roads. As a result, the Road Transportation Authority can, as of July 2017, authorize permits and supervise trials in accordance with the new law.

The country is well-rated by the World Bank for road infrastructure but has a tenth of the electric vehicle charging stations of the Netherlands for three times its road network. It is strongly rated by both KPMG's *Change Readiness Index* and the World Economic Forum in consumer acceptance, but only a tenth of Swedes live in an AV test area.

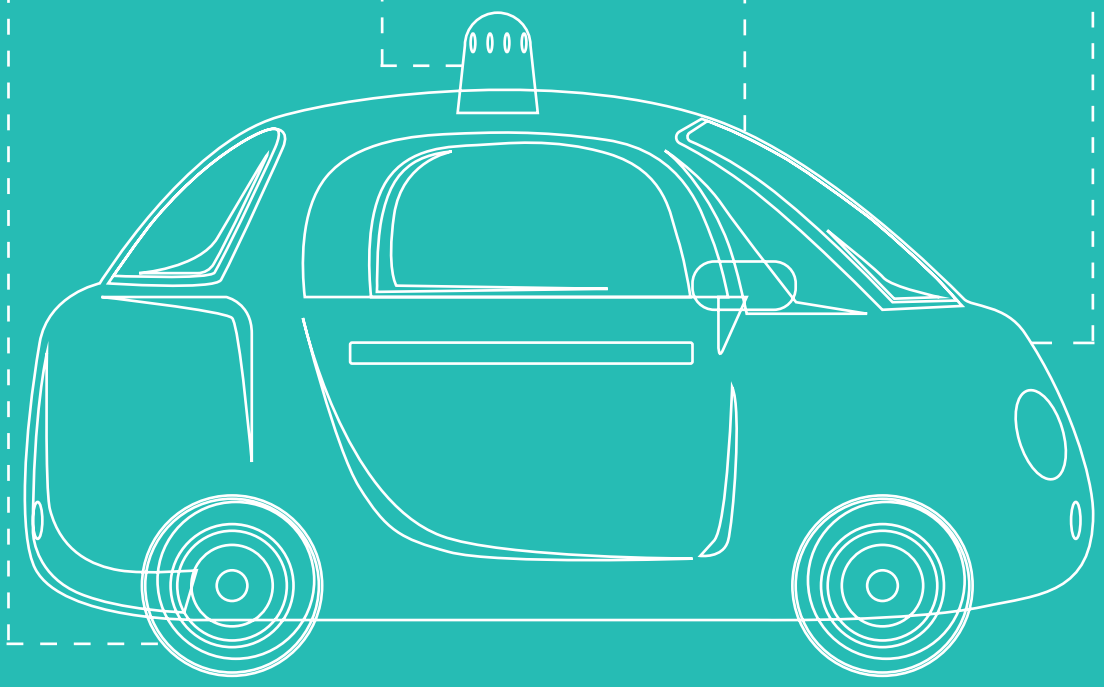
> The Swedish market is more mature than most in terms of AV. Swedish industry has a tradition of striving for innovative and highly technical solutions, closely linked to both research and development and governmental bodies. In addition, it is willing to adopt more sustainable solutions, which may enable flexible and innovative thinking around transportation.
>
> **— Christoffer Sellberg**
> Sector Lead, Automotive and Industrial Manufacturing, KPMG in Sweden

17. https://www.thelocal.se/20160818/look-no-hands-volvo-teams-up-with-uber-in-self-driving-car-race, http://www.telecomtv.com/articles/automotive/ericsson-volvo-and-autoliv-form-swedish-venture-for-autonomous-vehicles-15929/
18. https://www.volvocars.com/intl/about/our-innovation-brands/intellisafe/autonomous-driving/drive-me

5 United Kingdom

4th	5th	10th	3rd

Key takeaways: The UK has begun changing regulations and offering financial support in order to introduce driverless cars by 2021. Improved road and mobile infrastructure would help its readiness.



The UK rates in the top five for three pillars, but only tenth on infrastructure. On technology and innovation, the country has good scores on industry partnerships and research and development hubs, as well as high ratings from the World Economic Forum on both technology availability and capacity for innovation, although it has fewer AV patents than other leading nations. On consumer acceptance, it has among the highest ratings from KPMG's *Change Readiness Index* and the World Economic Forum, although lower ratings for the proportion of people living in test areas and on consumer acceptance.

On policy and legislation, the UK is near the top in AV regulation, with the Department for Transport having determined that it is legal for driverless cars to operate on any public roads without permits or extra insurance[19] and the establishment of a Centre for Connected and Autonomous Vehicles. The government wants to have driverless cars on British roads by 2021 and plans to make further changes to regulations to support this. In his keynote budget speech on 22 November 2017,[20] the finance minister, announced more support for electric vehicles as the precursors to AVs, including a new GBP400m charging infrastructure fund.[21]

The UK has strong scores from the World Economic Forum for effectiveness of law-making and legal system efficiency in challenging regulations, but its rating across this pillar is lowered by fewer government-funded AV pilots and a lower rating on government capability in KPMG's *Change Readiness Index* research.

Its mid-table performance on infrastructure is due to one of the lowest scores for 4G coverage, along with significant improvements which may be required to the road network. It is third on charging station density, but the Netherlands is so far ahead that this adds little to the UK score.

The UK has carved out a niche as an attractive testing and proving ground for AV technology in Europe. This is shown by the range of AV-centered consortia that are benefiting from private and government funding to develop, test and refine AV technology. It has also announced various rounds of funding, including in 2016 GBP390 million for low emission and AVs.[22] By not ratifying the Vienna Convention on Road Traffic and allowing the piloting of fully autonomous vehicles on public roads without need for primary legislation, the UK has created a supportive environment for the development of connected and AV technologies.

> The UK should be well placed for AV adoption, in light of its high population densities; particular issues around congestion, pollution and safety concerns; and its expected shift from personal vehicle ownership to mobility services, where fleets are more likely to adopt AV due to the cost of drivers."
>
> **— Christoph Domke**
> Director, Mobility 2030, Global Strategy Group, KPMG in the UK

19. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/401565/pathway-driverless-cars-main.pdf
20. https://www.gov.uk/government/publications/autumn-budget-2017-documents/autumn-budget-2017, section 5.4
21. https://www.gov.uk/government/speeches/autumn-budget-2017-philip-hammonds-speech
22. http://uk.reuters.com/article/uk-britain-eu-budget-autos/uk-government-announces-funding-for-autonomous-vehicles-electric-cars-idUKKBN13I1D3

6 Germany

> Germany believes it has the most innovative road traffic law in the world, governing interaction between drivers and vehicles with conditional or highly automated driving functions. However, there is a risk that the legislation could discourage AV use since the driver may be liable for damages, even if an accident is caused by the vehicle.

— Moritz Püstow
Partner,
KPMG in Germany

Key takeaways: Germany performs strongly on industry partnerships, research and development and road infrastructure quality, although consumers are yet to be persuaded of the benefits of AVs.

Germany is in the top five in the policy and legislation and the technology and innovation pillars, but is let down by mid-table rankings for infrastructure and consumer acceptance. On policy and legislation, it receives high scores on government investment in AV infrastructure and pilots, with its government legislating in 2017 to allow tests of self-driving cars on public roads,[23] and it rates consistently well on other variables.

In 2013, the Ministry of Transport established the Automated Driving Round Table, an advisory body linking industry, academia, associations and public administration.

On technology and innovation, it scores the highest marks on industry partnerships and on research and development hubs. Digital test beds financed with EUR100 million from the government include the Digital Motorway Test Bed established on the A9 motorway by the transport ministry, the state of Bavaria and automotive and technology industry bodies. Germany is second only to Japan on AV patents issued per capita.

But while the country has the highest possible score for road infrastructure and rates well on both road and mobile network quality, it has poor 4G coverage and a middling rating for technology infrastructure from KPMG's *Change Readiness Index*. It has no ongoing AV tests and a low acceptance of the technology by consumers, explaining its relatively low rank on consumer acceptance.

23. http://www.thedrive.com/tech/10215/germany-green-lights-self-driving-cars-with-new-law

7 Canada

> Southern Ontario has a perfect ecosystem to support AV research and testing. It is the fourth largest exporter of vehicles in the world, with manufacturing facilities for GM, Fiat-Chrysler, Ford, Toyota, Honda and their supply chains. Its Waterloo-Toronto Innovation Corridor includes research universities and technology companies, convincing Uber and General Motors to move jobs there.

— Gary Webster
National Leader, Infrastructure
KPMG in Canada

Key takeaways: Southern Ontario acts as a hub for Canada's industry, and the province has taken a lead by allowing companies including Uber and Continental to test AVs on public roads.

Canada rates well on technology and innovation, with the highest possible score for industry partnerships and high scores on both research and development hubs and AV technology company headquarters. However, it has very few patents in this area.

It gains maximum marks on government-funded AV pilots, with the province of Ontario having taken a particular lead as the only jurisdiction to have issued permits for AV testing on public roads.[24] In the last year, the province has issued seven permits to companies including Uber, tire-maker Continental, automotive supplier Magna and QNX, a Blackberry subsidiary.[25]

On infrastructure, Canada is well-rated for roads and mobile networks, with its major telecoms providers successfully testing 5G network technology — although other variables lead to a middling rank overall. On consumer acceptance it is one of the leaders in terms of people living in an AV test area and is well-rated by both KPMG's *Change Readiness Index* and the World Economic Forum.

24. http://www.mto.gov.on.ca/english/vehicles/automated-vehicles.shtml
25. https://www.itworldcanada.com/article/ottawa-blackberry-partner-to-test-canadas-first-self-driving-vehicle-on-a-public-road/397647

8

United Arab Emirates

> Dubai's desire to excel in the field of artificial intelligence, big data and data analytics, which it will overlay on its existing 'hard' infrastructure, will ensure that the UAE will be at the vanguard of the AV revolution. The learnings from its successful implementation of driverless trains and its initiative on flying taxis will ensure its leadership position in this field is maintained.

— Ravi Suri
Partner, Advisory,
KPMG in the United Arab Emirates

Key takeaways: The UAE has the highest rating of the 20 countries for road quality, an important factor in infrastructure readiness. It could build on this through encouraging private-sector innovation.

The UAE scores well on both policy and legislation and on infrastructure. On the former, it is credited for having a specific AV function within its transport department, for quality of regulation and for government capability in KPMG's *Change Readiness Index*. On infrastructure, it has the highest ratings of all 20 countries in this research for road quality from the World Economic Forum and for technology infrastructure from the *Change Readiness Index*.

However, the research suggests that the UAE lacks AV technology company headquarters, patents or investments, largely explaining its lower rating on technology and innovation. Consumer survey data shows a high level of acceptance of AV technology, but KPMG's *Change Readiness Index* rates the country lower than others for people and civil society's use of technology.

9 New Zealand

2nd 12th 16th 5th

> New Zealand is affluent and large enough to support meaningful product trials, but small enough to prevent teething troubles damaging the reputation of a technology or company. Microsoft, Facebook and drone delivery company Flirtey have used it as a development lab. Christchurch has hosted the world's first fully AV trial at an international airport.

— Jesse Phillips
Director, Deal Advisory
KPMG in New Zealand

Key takeaways: The NZ Transport Agency supports companies testing AVs, building on the country's reputation as a technology test-bed. Better infrastructure would help the country become more AV ready.

New Zealand is second only to Singapore on policy and legislation, with high scores for its AV regulation and having a specific department to deal with this. The country has no specific legal requirements for cars to contain drivers, the NZ Transport Agency can provide support to those undertaking testing, and it is collaborating with Australia to minimize duplication and share knowledge.[26,27] It is also highly rated by the World Economic Forum for law-making and legal system efficiency. The country is perceived as having a clear, straightforward regulatory framework, with government agencies accepting the need to adapt legislation to new technology.

The country is fifth on consumer acceptance due to good ratings from KPMG's *Change Readiness Index* and the World Economic Forum, as well as having AV tests in areas covering a significant proportion of the population. It also offers a wide range of climatic conditions within a relatively small area.

New Zealand scores less well on technology and innovation, with no AV company headquarters, patents or investment found in the research, although it has the third-highest market share of electric cars. New Zealand's future performance on innovation could be boosted by a trial of satellite-based augmentation system technology, which its government is carrying out with Australia to improve the accuracy of positioning systems such as GPS.[28] It is in the bottom five of our sample on infrastructure due to low levels of 4G coverage outside of heavily populated areas, few electric charging stations and middling ratings for road quality and road infrastructure.

26. http://www.transport.govt.nz/ourwork/technology/specific-transport-technologies/road-vehicle/autonomous-vehicles/testing-autonomous-vehicles-in-nz/
27. http://wardsauto.com/technology/oz-new-zealand-follow-singapore-s-autonomous-lead
28. https://www.linz.govt.nz/data/geodetic-services/australasian-sbas-trial

10 South Korea

> To enhance public acceptance, by the end of 2017 the South Korean government is planning to launch an unmanned autonomous shuttle service as a demonstration project. During its Winter Olympics in February 2018, the country will carry out AV demonstrations from Seoul to PyeongChang and provide autonomous shuttle services near the stadium.

— Hyo-Jin Kim
Head of Infrastructure,
KPMG in Korea

Key takeaways: South Korea's 2018 Winter Olympics will showcase AVs, and the country is a leader on piloting and testing. More locally-based companies would allow it to take commercial advantage of this.

South Korea is fourth on infrastructure, with the best 4G coverage of the 20 countries in this research; such networks are available to users 96 percent of the time.[29] In general, it has excellent mobile networks as well as good quality roads. It is mid-table on technology and innovation, scoring top marks on industry partnerships and research and development hub presence and well on patents. However, it has few AV technology company headquarters, low usage of electric cars and Uber has little presence in the country, with its UberX service unavailable following regulatory action[30] in 2014. However, Kakao Taxi, a local alternative, has several million users.

The country scores well on AV-specific policy and legislation variables, with maximum points for government investment in pilots and AV infrastructure. The government claims that its K-City facility, opened in October 2017, with a target of completion by next year, is the world's largest test bed for self-driving cars.[31] It has also authorized AVs to operate temporarily on public roads, with research licenses issued to Naver Labs, Hyundai Motor, Seoul National University, Hanyang University, Hyundai Mobis, Traffic Safety Corporation and KAIST. Its weaker overall rating in this pillar is due to low scores from both KPMG's *Change Readiness Index* and the World Economic Forum.

29. https://opensignal.com/reports/2017/06/state-of-lte
30. https://www.cnbc.com/2017/04/26/uber-south-korea-law-court.html
31. http://www.businesskorea.co.kr/english/news/sciencetech/18018-k-city-world%E2%80%99s-largest-test-bed-self-driving-cars-be-opened-korea

11 Japan

12th 7th 3rd 16th

> Much of the expectation for AVs in Japan is based on how such technology can help its aging population. There has been an increase in the number of car accidents involving older drivers and AVs would allow them to drive with comfort and safety.

— Mina Sekiguchi
Managing Director,
Advisory Planning,
KPMG in Japan

Key takeaways: The government has big ambitions for AVs and Japan has the most patents per capita of the 20 countries. More local testing could help lift consumer cynicism about the technology.

As with South Korea, Japan does very well on infrastructure but less so elsewhere. Its third place on infrastructure is due to 4G network availability second only to South Korea and high ratings for its roads, road infrastructure and mobile network quality.

The country wants to build the world's best intelligent transport system to support AVs,[32] but it receives middling scores on AV-specific policy and legislation variables, although it does well on government funding of pilots. A May 2017 road map states the government's aim to have the world's safest road transport by 2020 and to build and maintain "a society with the world's safest and smoothest road transport" by 2030. It also wants to expand the export of intelligent vehicles and infrastructure via public-private collaboration and to become a global hub of innovation. The 2020 Tokyo Olympics and Paralympics have been set as a landmark to demonstrate Japan's capabilities.

On technology and innovation, Japan has the highest number of AV-related patents of any country in this research, adjusted for population, and receives high marks for industry partnerships. However, it has relatively few AV technology company headquarters and Uber has a low market presence in the country. Its consumers are among the most cynical about AV technology and very few live in test site cities, contributing to its bottom-five ranking for consumer acceptance.

32. http://japan.kantei.go.jp/policy/it/2016/itsinitiative_roadmaps2016.pdf

12 Austria

> Autonomous driving has become a very significant issue for Austrian authorities, and offers great opportunities for the public and for the country's economy. A multi-year funding plan has been set up to support technology-based research and Austria has legislated to facilitate the testing of AVs on specific public roads.

— Werner Girth
Partner, Advisory,
KPMG in Austria

Key takeaways: Government and industry have jointly funded a EUR280m research center, part of a range of research and testing plans that may accelerate Austria's use of AVs in future.

Austria is middle-rated on all four pillars. On policy and legislation, it scores well on government investment on AV infrastructure, for having a specific department and for the number of government funded pilots, including half of the EUR280 million funding for a research center with the rest coming from industry,[33] but has a relatively low rating from the World Economic Forum for the effectiveness of its law-making.

In terms of technology and innovation, Austria is credited with the presence of research and development hubs for AVs and, to lesser extent, for industry partnerships. The Austrian Light Vehicle Proving Region for Automated Driving (ALP.Lab), an association of automotive and industry research organizations, aims to provide test tracks, technology to record data and an exhaustive simulation environment. In addition to this, the city of Salzburg plans to integrate a fully autonomous bus in its public transport system and the Austrian Armed Forces aim to introduce AVs on military training areas in the near future. However, the country has few company headquarters of patents and the research found no investments.

The high quality of Austria's mobile networks, roads and road infrastructure are recognized in the infrastructure pillar, although it has few electric charging stations. Its middling showing on consumer acceptance is partly due to no ongoing AV tests, balanced by good ratings from KPMG's *Change Readiness Index* and the World Economic Forum.

33. http://www.ctr.at/en/news/news-press/details/news/ctr-bringt-sensorik-mikrosystemtechnik-kompetenz-in-silicon-austria-ein/

13 France

France has large companies including Renault, PSA-Opel, Transdev, Valeo and Safran as well as startups such as Navya and Easymile investing heavily in AV. Although it has been slow to develop awareness, the French government is now proactively working to regulate and promote development, with an ambitious strategic plan expected soon.”

— Bertrand Vigner
Partner, Strategy Group,
KPMG in France

Key takeaways: Renault and PSA are working with startups and local authorities on AV pilots, and the French government is working with Germany on cross-border tests.

France does reasonably well on AV-specific scores on its lowest-rated pillars, policy and legislation and infrastructure. with a legal framework adopted to allow the testing of driverless cars on public roads in 2015, which was broadened the following year.[34] With Germany, the French government has announced plans to test self-driving vehicles on a cross-border road from Metz in France to Merzig in Germany.[35] However, the country is rated poorly for government capabilities by KPMG's *Change Readiness Index* and by the World Economic Forum on law-making and legal system efficiency.

On infrastructure, France is credited with having excellent roads and good road infrastructure, but poor 4G coverage and a low density of electric charging stations.

It does better on technology and innovation, including its establishment of the public-private VeDeCom Institute to deliver an affordable autonomy by 2020. Among its leading companies in the automotive sector, Renault is working with the local authority in Rouen and public transport operator Transdev aims to establish an on-demand mobility service on pre-set routes from spring 2018, while PSA Group[36] is working with start-ups AIMotive[37] and nuTonomy[38] — the latter to deploy customized Peugeot 3008s on public roads in Singapore. Part-maker Faurecia has announced a partnership with its German rival ZF Friedrichshafen to swap technological expertise.[39]

France is also well rated on research and development hubs and in the World Economic Forum ratings. French consumers are fairly enthusiastic about AV technology, but the country has a middling score on people's technology use in KPMG's *Change Readiness Index* research.

34. https://readwrite.com/2016/08/06/france-autonomous-car-trials-tl4/
35. http://www.industryweek.com/emerging-technologies/germany-france-plan-cross-border-self-driving-test-zone
36. https://techcrunch.com/2017/09/06/psa-group-and-aimotive-team-up-for-french-self-driving-pilot/, Renault one https://insideevs.com/renault-to-ready-4-zoes-for-autonomous-on-demand-mobility-service/
37. https://techcrunch.com/2017/09/06/psa-group-and-aimotive-team-up-for-french-self-driving-pilot/
38. https://techcrunch.com/2017/05/03/nutonomy-peugeot-citroen-groupe-psa/
39. https://global.handelsblatt.com/companies-markets/part-exchange-844806

14 Australia

> AV are one of the major disrupters hitting the transport system in the next 10 years in Australia. Others include road pricing, mobility as a service and increasing contestability in public transport operations. These will drive different institutional and regulatory structures that will challenge the historical model of transport agencies with their focus on infrastructure development and system regulation.

— Paul Low
Partner Management Consulting,
KPMG in Australia

Key takeaways: Several Australian cities are hosting trials and the country has excellent mobile networks. Improvements to roads and electric charging infrastructure would help with its AV readiness.

Australia scores reasonably well on AV-related policy and legislation, slightly less so in general ratings from KPMG's *Change Readiness Index* and the World Economic Forum. In May 2017 the country issued national guidelines for trials of AVs on its roads, with these requiring specific exemptions from state and territory governments.[40] At present, the law says that an automated driving system cannot be the driver of an AV, meaning that although a vehicle may be partially automated, the human occupant will need to be the legal 'driver', be held responsible for any incident that may occur while in control of the vehicle and must exercise proper control over the vehicle at all times.

On technology and innovation, Australia has few AV technology company headquarters and patents, the research found no relevant investments and few Australians drive electric cars, although it receives credit for a strong Uber presence and for general availability of technology. AV trials are taking place or are planned in several cities, including Sydney, Melbourne, Perth and Adelaide.

On infrastructure, Australia receives the maximum score for the quality of its mobile networks but only middling ratings for the quality of its roads and availability of 4G and it has very few electric charging stations. The country is very highly rated for people's use of technology by KPMG's *Change Readiness Index*, but few people live in test areas and consumer research suggests Australians are fairly cynical about the technology.

40. https://www.itnews.com.au/news/guidelines-for-australian-driverless-vehicle-trials-released-462904

15 Spain

15th 16th 14th 17th

> AV technology has to address some challenges to reach mass implementation, like perceptions about customer safety, economic accessibility, and finding significant investment to adapt infrastructure. The implementation of pilot projects by public bodies and institutions will help to increase consumer acceptance.”
>
> — **Ovidio Turrado Sevilla**
> Head of Infrastructure,
> KPMG in Spain

Key takeaways: A November 2017 government innovation plan, which aims to develop AVs in Spain over the next few years, may help tackle low acceptance of the technology by consumers.

Spain ranks between 14th and 17th on each of the four pillars of this research. It receives fairly strong scores for its AV-specific regulation and government work, having published a legal framework allowing testing on public roads as early as 2015, but has weaker ones from KPMG's *Change Readiness Index* and the World Economic Forum. A government innovation plan published in November 2017 includes some important steps to develop the required ecosystem and to promote AVs in Spain. It includes strategic planning for the implementation of 5G networks among roads and railways, a plan for electric and hybrid vehicle promotion to be launched in 2019, and technical standardization, legal framework development and development of a white paper on the ethics of AVs, all planned for 2020.

The research found no AV technology companies based in the country and very few relevant patents, although it gains middling scores for industry partnerships and research and development hubs.

On infrastructure, the relatively high quality of Spain's roads and mobile networks is undermined by a very low density of electric charging stations and middling levels of 4G coverage. It does not have any ongoing AV tests and Spaniards are the least likely to accept AV technology according to consumer survey data, leading to its low ranking on consumer acceptance.

16 China

16th 15th 15th 15th

China can position itself as a world leader, with expectations that AVs will be capable of being deployed by 2025-2030. Key drivers include the scale of China's auto industry as the largest market in the world by production and sales and its focus on technology and innovation, supported by the 'made in China 2025 plan'.

— Philip Ng
Partner, KPMG in China

Key takeaways: China, which already has a high density of electric vehicle chargers, has strong hopes for AV technology. More accurate public mapping would help it achieve AV readiness.

China receives average scores across the researched pillars, but is clearly ahead of the bottom four countries in our sample. On policy and legislation it receives middling scores for AV-specific regulation and work, although there are specific problems from some government regulations, for example, requiring public maps to be no more than 50 meters accurate[41] and stating that drivers must keep both hands on steering wheels.

The country scores well for industry partnerships and research and development. Recent work has included a rapid development of sensor technology, optimized chips for AV, artificial intelligence in computer vision, voice recognition and routes planning and vehicle-to-everything (V2X) communications. AV is being piloted and deployed in areas such as self-service delivery cars in enclosed residential areas and automated trucks on selected high-speed roads. However, the country has a very low number of AV technology company headquarters, patents and investments and poor scores from the World Economic Forum in this pillar. As Uber is no longer active in China, the research uses customer numbers for Didi Chuxing, China's ride-sharing company.

On infrastructure, China has the second-highest density of electric charging stations — although this is less than a fifth of the Netherlands figure — and an above-average rating for its 4G coverage, but is undermined by poor ratings for roads and a very low score for technology infrastructure. China has one of the highest consumer acceptance scores, but very few people live in test areas.

41. https://www.brookings.edu/wp-content/uploads/2016/09/driverless-cars-3-ed.pdf

17 Brazil

> In terms of specific regulation, we haven't seen discussions on AV but there is a new automotive sector regulation called 'Rota 2030' being discussed by government, which may include some initial related topics. AV discussions are starting in forums and events related to the automotive and telecom industries, but we still haven't seen city authorities or governments planning around it."

— Mauricio Endo
Head of Government & Infrastructure, Advisory, KPMG in Brazil

Key takeaways: Brazilians tend to be early technology adopters and the country has good mobile networks, but it will need to improve on regulations, local innovation and road quality to take advantage of AV.

Brazil is the first of four bottom four countries in our study, all of which are some way behind the other 16. It has the weakest scores of the 20 countries for policy and legislation, with low scores for AV-specific regulations and government work and even lower ones from KPMG's *Change Readiness Index* and the World Economic Forum for general government and legal system capability. However, Uber operation has been authorized in large cities in the country since 2016 and Brazil is considered one of the largest operations of Uber globally.

On technology and innovation, Brazil shares the bottom spot with Russia on market share of electric cars which are not generally available, although hybrid cars are starting to be imported. It received the lowest scores on research and development hubs, AV technology company headquarters, patents and investments.

On infrastructure it has a good coverage of 4G (more than 90 percent of cities are covered), but very few electric charging stations and only Russia has worse roads. Consumer data suggests Brazilians are the keenest of all those in the 20 countries on AV technology, mobile phone penetration is more than 100 percent of the population and Brazilians are known for being early adopters of new technologies. Despite this, the country gets the lowest rating for people's use of technology in KPMG's *Change Readiness Index*, which measures specific factors including internet access in schools and the use of mobile phones to pay utility bills.

18 Russia

> Until now, the government has not granted significant priority to AV implementation issues. However, after the president's recent announcement of a transition to digital economy, we are observing an increase in regulatory activity, which may end up with the development of relevant regulations within the next 2–3 years.

— Vadim Toporov
Senior Manager, Advisory,
KPMG in Russia

Key takeaways: Russia's government is offering US$10 million in subsidies to local companies to create its own AV industry. Infrastructure and legislative changes would also be required to be AV ready.

Russia receives the lowest rating of the 20 countries in both the technology and innovation and infrastructure pillars. On technology and innovation, it is at the bottom of the table for AV company headquarters, patents, investments and percentage of electric cars as well as overall capacity for innovation. On infrastructure, Russia has the lowest possible scores on road quality and infrastructure, very poor 4G coverage and a very low density of electric charging stations.

Russia's government wants to do better, although it is looking to local companies to achieve this. August 2017 saw prime minister Dmitry Medvedev announcing the government's intention to create suitable infrastructure for driverless vehicles in large cities and on major roads, with US$10 million of subsidies available and an ambition to build a Russian electric and driverless vehicle industry from scratch.[42] Russian companies including internet firm Yandex and truck-maker Kamaz are working on tests.[43]

However, advances in technology and innovation by Russian companies are not supported. The absence of legislation allowing usage of AV on public roads and lack of infrastructure are cited by AV technology companies as the main obstacles.

42. http://www.ewdn.com/2017/08/16/russia-prepares-plans-to-develop-high-tech-infrastructure-for-driverless-transport/
43. https://www.rbth.com/business/2017/07/03/russia-takes-the-fast-lane-into-the-world-of-driverless-vehicles_794665

19 Mexico

"The current energy reforms are expected to privilege oil and gas production, which will create a conflict given AVs are mainly electric. Mexico faces challenges in legislation, technology and infrastructure to be ready for AVs, although it will get there as the country becomes more integrated with the US and Canada."

— Ignacio Garcia de Presno,
Global Infrastructure and Projects Group, KPMG in Mexico

Key takeaways: AV adoption in Mexico currently faces a range of barriers, with a lack of specific regulations, no active tests and little industrial activity. Integration with the US may change this in future.

Mexico is weak across each of the four pillars, without being worst in any. On policy and legislation, it scores low on both AV-specific and general variables, with no apparent regulations on AV testing on public roads and very limited testing so far. The country's current economic and political condition creates barriers for taking actions in order to adopt AV in the near future.

It gets the lowest scores on industry partnerships, research and development AV hubs, patents and investments and the research has found no AV technology company headquarters, although the World Economic Forum gives the country a middling score for availability of the latest technology.

On infrastructure, Mexico's roads receive a slightly below average rating for road quality, but lower scores on other variables. There are no active AV tests, contributing to its low rating on consumer acceptance.

20 India

> While the degree of readiness for autonomous transportation might vary across countries, the overall economic and social benefits of driverless cars may make it impossible for a country like India to ignore this exciting technology for long.
>
> **— Santosh Kamath**
> Partner and Lead for Renewable Energy, KPMG in India

Key takeaways: Consumers appear enthusiastic about AVs and the government has ambitious targets for electric vehicle usage, but its effective ban on AVs and poor road quality hinder its AV readiness for now.

India is among the bottom three countries in all four pillars of the index. Its government has effectively banned AVs, with road transport and highways minister Nitin Gadkari saying in July 2017 that it would not allow driverless cars as they would take people's jobs.[44] As a result, India has been given a score of zero in many policy and legislation categories, including those covering regulation and government investment.

India has ambitions, with its Automotive Mission Plan aiming to bring its automotive industry into the top three in the world in engineering, manufacturing and export of vehicles and components. The government of India has also set an ambitious goal of achieving 100 percent electric vehicle mobility by 2030. However, it scores poorly on road safety, accounting for 10 percent of global road accidents according to the International Road Federation.

Given the overall socio-economic benefits of autonomous transport and the strong entrepreneurial ecosystem, India could become an important AV market in the long term. But at present, on technology and innovation it scores minimally for lack of patents and investments and low usage of electric cars. On infrastructure, it scores poorly for mobile network quality and in KPMG's *Change Readiness Index* technology infrastructure rating. On consumer acceptance, survey data suggests Indians are among the most accepting of AV technology — but the evidence from the rest of the data is that they are unlikely to get much chance to use it.

44. http://www.hindustantimes.com/india-news/won-t-allow-driverless-cars-that-take-away-jobs-says-union-minister-nitin-gadkari/story-JCDjBMoDQ4yzXrWv3ltxsK.html

Conclusion

AV technology is developing very rapidly. It is rare for a week to pass without a major manufacturer, city or region announcing a new product alliance, trial or investment.

Private-sector research and testing is an essential element in the development of AV, with three of the top five countries in this index's first edition having significant domestic AV capability. But on its own it is not sufficient, as reflected in the US' third place. While the US is the clear global leader on innovation, it has an average rating on legislation and does little better on infrastructure. Sweden and Germany, which are second and third on technology and innovation, are similarly let down by moderate performances elsewhere.

Road transport relies on the quality of road infrastructure as well as the regulatory environment that determine access to that infrastructure. Strong performances in both these areas give Singapore the second-highest score in the index, despite a less impressive rating on technology, and boosts the overall rank of the UAE. Poor showings on infrastructure undermines the ambitions of the UK, Canada and New Zealand.

The Netherlands leads this index because it performs strongly across all four pillars of research, showing how both its private and public sectors are highly engaged. It is already a big user of electric vehicles but it also has excellent infrastructure and a government determined to take advantage of AV.

So what would it take to accelerate the application of AV technology in your country, state or city? Based on our experience, conversations around the world and the findings of this index we would highlight three areas for particular focus:

1. Plan today for an AV future, by revising national and local transport strategies and spatial development blueprints. Support the introduction of electric vehicles through measures to increase the number of electric charging points. Invest in high-quality AV-ready road infrastructure and next generation mobile communication technologies. Consider strategies to mitigate the likely impact on jobs in the taxi and trucking industries. Develop alternative revenue streams to offset the loss of fuel tax. Revise laws as necessary to ensure vehicles are safe, insurance regimes remain robust and data security and data privacy concerns are met. It is not a question of if but when AV becomes ubiquitous in the world, yet most authorities continue to invest scarce resources on the basis of transport and spatial development plans which are rapidly becoming obsolete, while ignoring their impact in other areas.

2. Embrace partnerships between public authorities and private sector developers, as Singapore in particular is doing. Measures including specific legislation to remove regulatory barriers, a dedicated organization within government to drive AV adoption, and proactive engagement with developers to support AV pilots and help fund innovation should help speed the development of the technology and also ensure that its application meets public policy objectives.

3. Bring together all the key stakeholders. We should recognize that this is not just about transport but about how we as citizens in our communities will live and work. We will maximize the economic, environmental and road safety benefits for society if we engage as widely as possible in thinking through what AV means for the future.

KPMG's Public Transport network is working with public authorities across the world to help them respond to the AV opportunity. Please contact us, through any of our mobility leaders listed at the end of this report, to explore how we can help you.

Appendices

Appendix 1: Pillar analysis

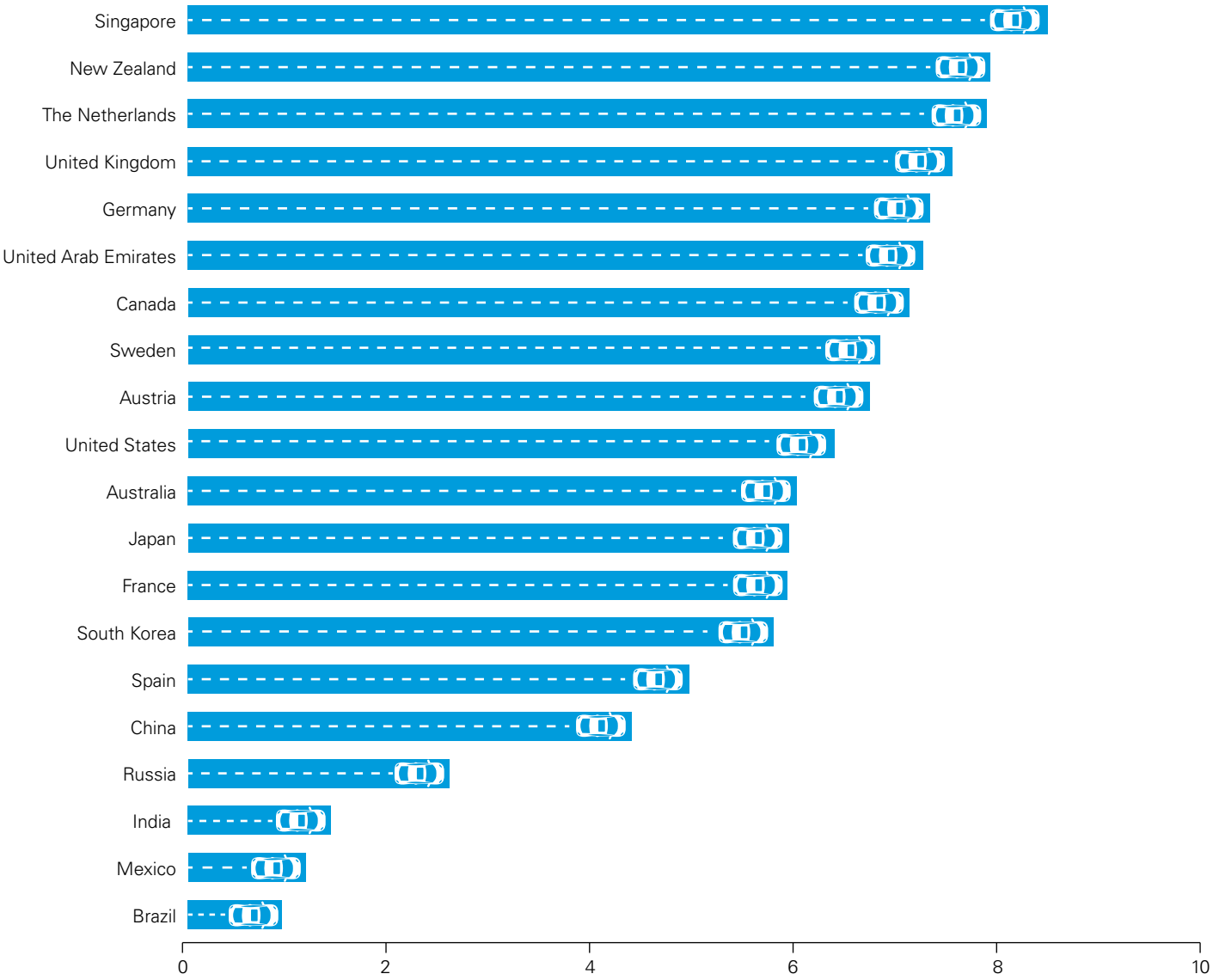
Policy and legislation

The policy and legislation pillar is based on seven variables, four scored specifically for this index and three drawing on existing research. Singapore is the clear leader, followed by New Zealand — outperforming its overall ninth place — and the Netherlands. The US significantly underperforms in this pillar, lying tenth. The bottom four countries, in this pillar and in the index as a whole, score significantly less than the others although Russia is above the other three (see chart below).

The four variables scored for this index are quality of AV regulations; whether the country has established an AV department within the government's transportation department; government investment in AV infrastructure; and number of government funded AV pilots. Singapore gains maximum scores in three of these categories and the Netherlands in two. India scores zero in all four, given its apparent ban on AVs. The full scores for these four variables are detailed on page 43.

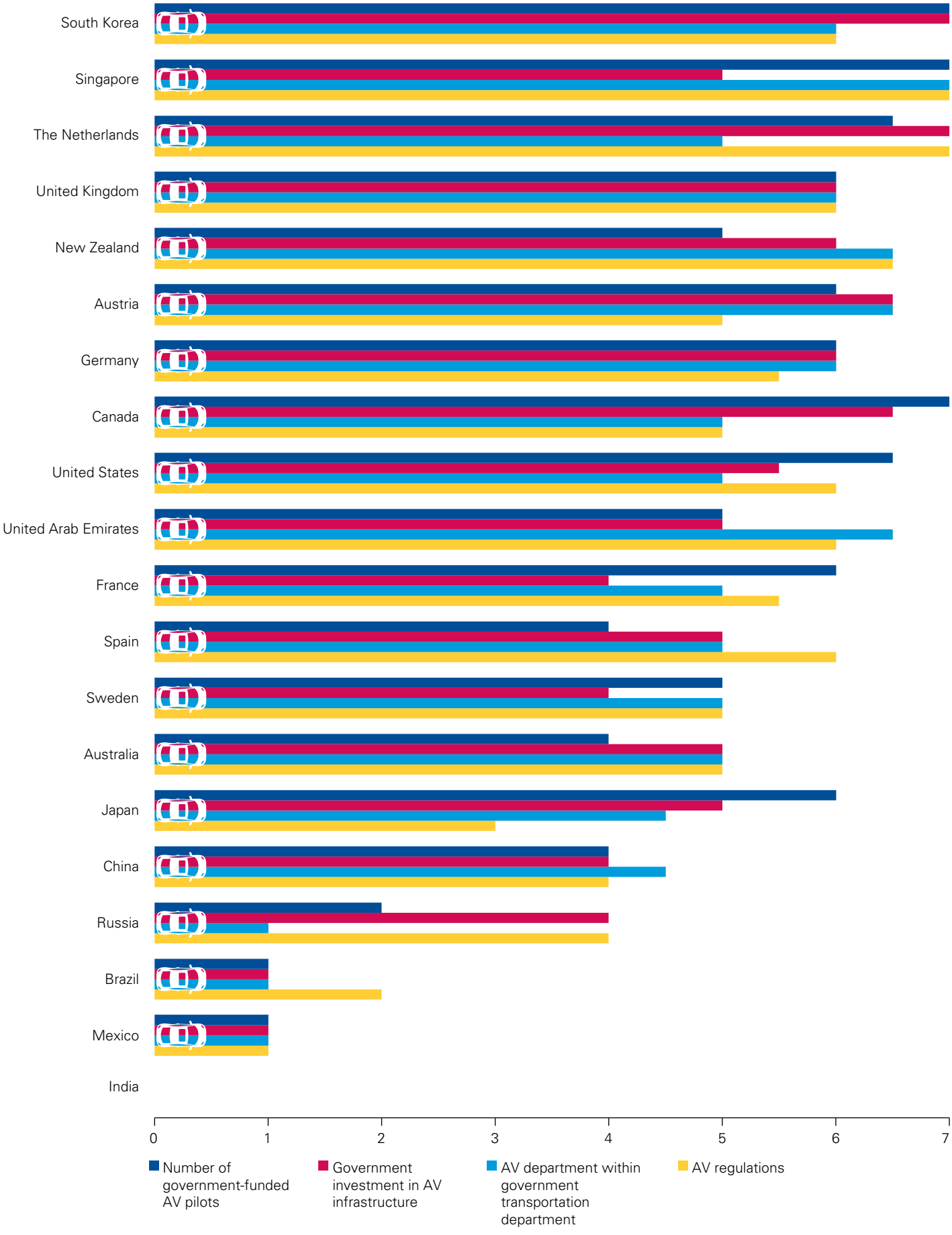
The other three variables are the KPMG *Change Readiness Index's* score for government capability and the World Economic Forum's ratings for the effectiveness of law-making bodies and the efficiency of the legal system in challenging regulations. Singapore receives the maximum scores and Brazil the minimum for the first two. New Zealand gains top marks, with Russia getting the least, for the legal system efficiency measure.

Policy & legislation pillar: score by country



Source: *Autonomous Vehicle Readiness Index*, KPMG International, 2017

Policy & legislation pillar: AV specific variables by country



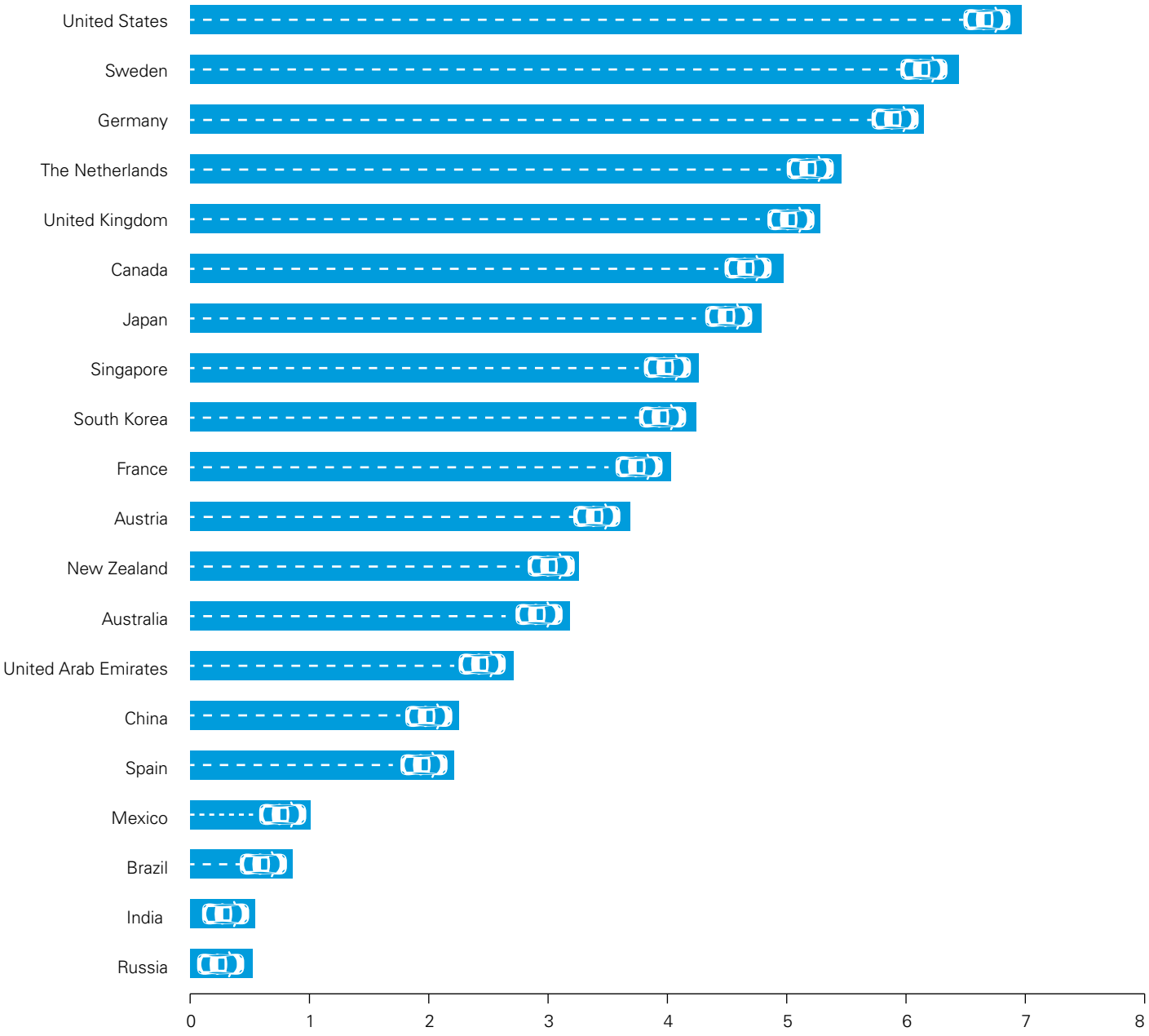
Source for each is: *Autonomous Vehicle Readiness Index*, KPMG International, 2017

Technology and innovation

Scores for technology and innovation pillar are based on nine variables, two scored specifically for this index, five drawing on existing research and one calculated from data published by Uber. Singapore and the UAE notably underperform in this pillar, lying eighth and 14th, respectively. Unlike the policy and legislation pillar, where around two-thirds of countries gain a good score, technology and innovation scores decline fairly smoothly from the lead set by the US, Sweden and Germany, although the bottom four countries are clearly behind the rest.

The US gains the maximum score in five of the nine variables in this pillar: industry partnerships, research and development AV hubs, total investments and both the World Economic Forum ratings. Germany and South Korea also score maximum marks on the first two variables, and Canada on the first. Sweden is just ahead of the US on AV technology company headquarters, scaled by population. Singapore scores 100 percent on Uber market presence, as the company serves all of the city-state. Brazil, Mexico and Russia score zero on five out of the nine variables,

Technology & innovation pillar: score by country



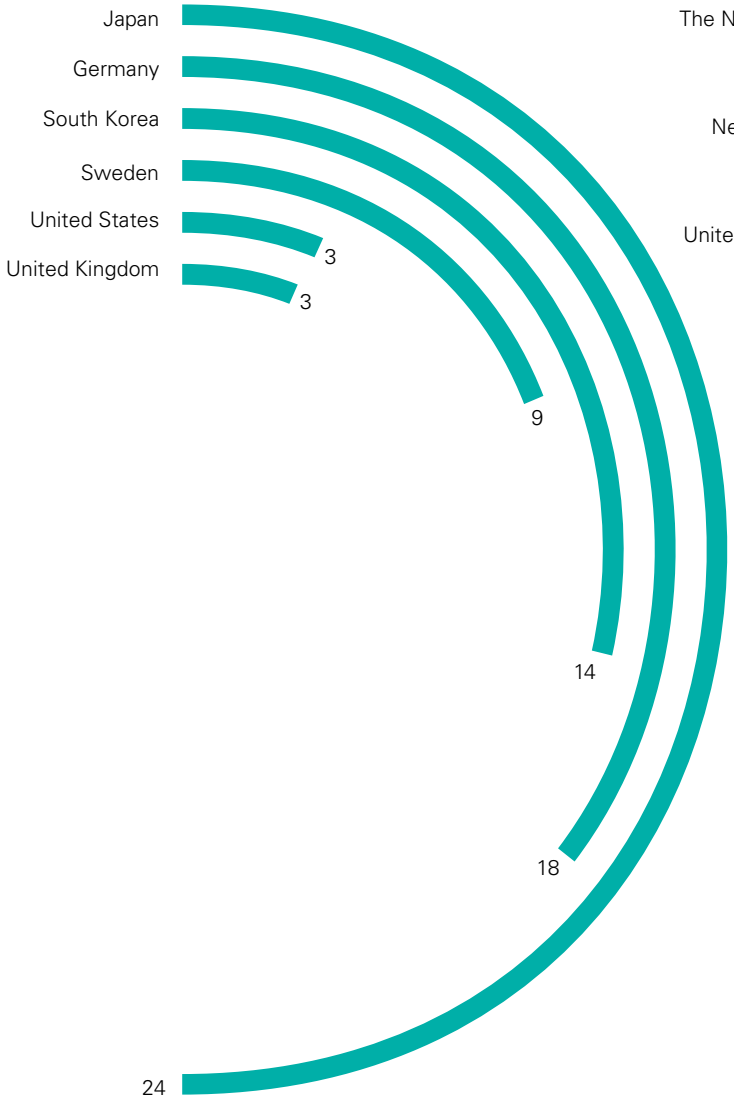
Source: *Autonomous Vehicle Readiness Index*, KPMG International, 2017

including patents and investments for all three countries.

Several of the variables have runaway winners, resulting in low scores for most other countries. A set of nearly 7,500 patents relating to AVs in the 20 countries includes 3,089 issued in Japan, 1,482 in Germany and 915 in the US. These scores are adjusted for population, leaving Japan, Germany, South Korea and Sweden as the only countries scoring a quarter of a point or more for this variables.

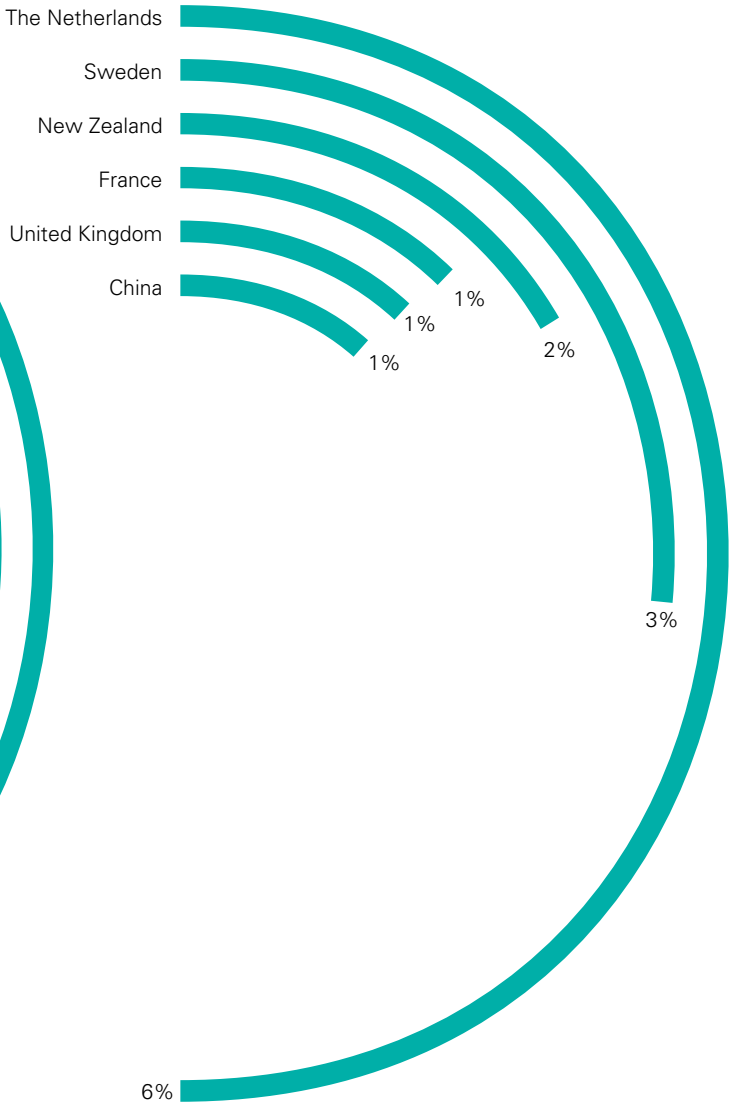
Use of the Brookings Institution's data on 160 AV investments over the last three years, assigned to countries and again scaled by population size, gives only the US, Germany, Sweden, UK, Canada and France more than a quarter-point and nine countries zero. On electric vehicle (EV) market shares, data from the Global EV Outlook report provided an even narrower focus: the Netherlands' 6.39 percent share is far more than Sweden's 3.41 percent. It should be noted that Norway — which is not included in this edition of the index — outscores both, with 28.76 percent of its car fleet now being electric.

AV patents per million people



Source: *Autonomous car-control mechanism*, Patent Insight Pro

EV market share



Source: *Global EV Outlook 2017*, International Energy Agency

Note: Numbers are scaled by national population.

Infrastructure

The rating for infrastructure is based on six variables, all drawn or based on existing research. The Netherlands is the clear leader, followed by Singapore. Japan and South Korea, in third and fourth places, both significantly outperform their overall rankings of 11th and 10th respectively, while Germany and the UK perform poorly. The four lowest-ranked countries, the same as in the overall index, are again some distance behind the other 16.

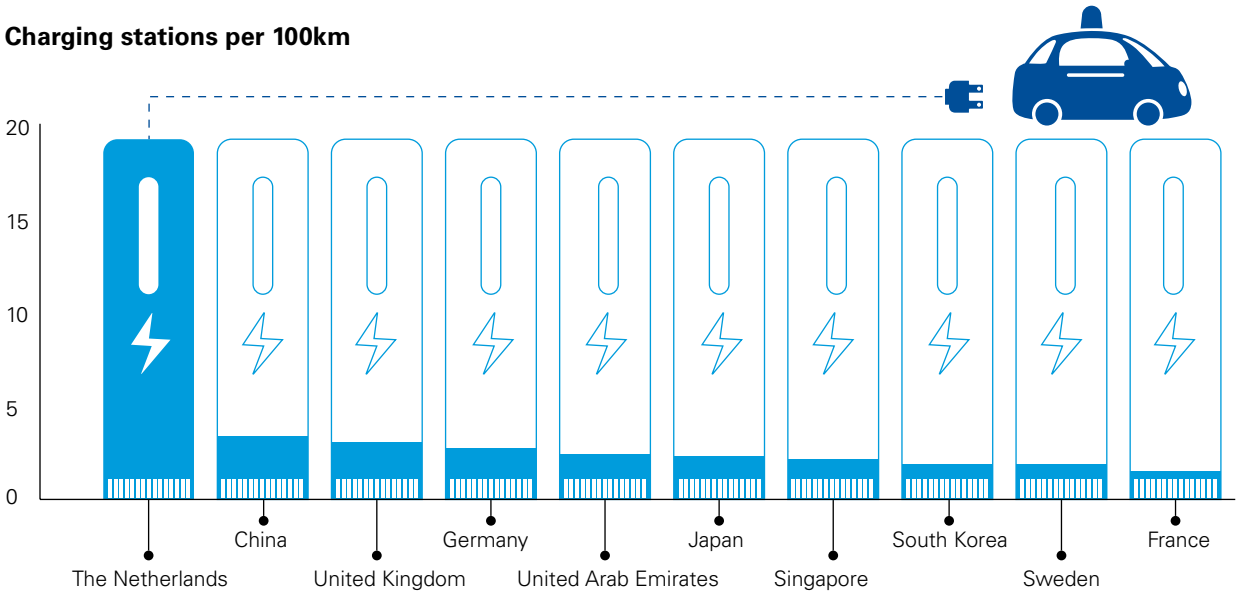
Infrastructure pillar: score by country

Source: *Autonomous Vehicle Readiness Index*, KPMG International, 2017

One specific variable on a country's readiness for AVs is density of electric vehicle charging stations, partly as most AVs are likely to be EVs, partly as it reflects a country's willingness to update the road network for new technologies. The variable is based on total number of EV charging stations divided by the length of paved road in each country.

There are very big differences: the Netherlands has around 19 EV stations for each 100 kilometers of road, China and the UK are the only other countries with more than three in that distance, and eight countries have less than one. This is one of the variables that helps the Netherlands gain its top place in the index.

Charging stations per 100km

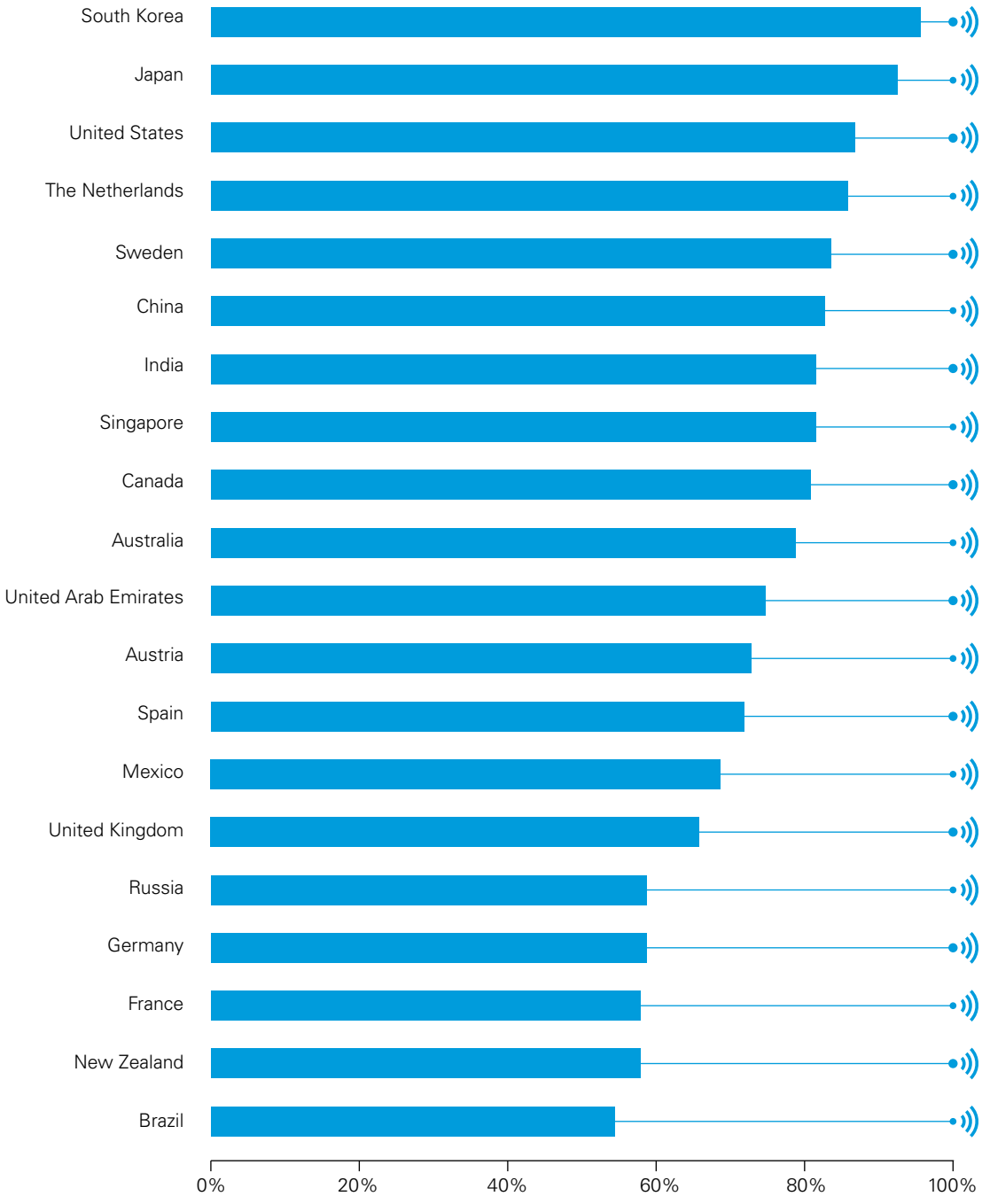


Source: *Global EV Outlook 2017*, International Energy Agency

Other variables in this pillar serve as a reality check on countries' ambitions for AVs, which require high-quality roads and high-speed mobile data networks to operate well. As the current standard in mobile internet is 4G, a measure of its availability is used, ranging from 96 percent in South Korea, followed by Japan and the US, to 55 percent in Brazil. Some economically advanced countries, including France, Germany, New Zealand and the UK, perform poorly on this.

This pillar includes two variables on roads, one from the World Economic Forum covering general road quality and the other from the World Bank's Logistic Performance Index on road infrastructure from the point of view of logistics. The UAE scores the maximum for general road quality, Germany leads the road infrastructure category and the Netherlands, Singapore, Japan and Austria perform strongly in both. South Korea's strong mobile infrastructure and the UK's high ratings in a number of areas are undermined by their relatively poor roads.

4G availability

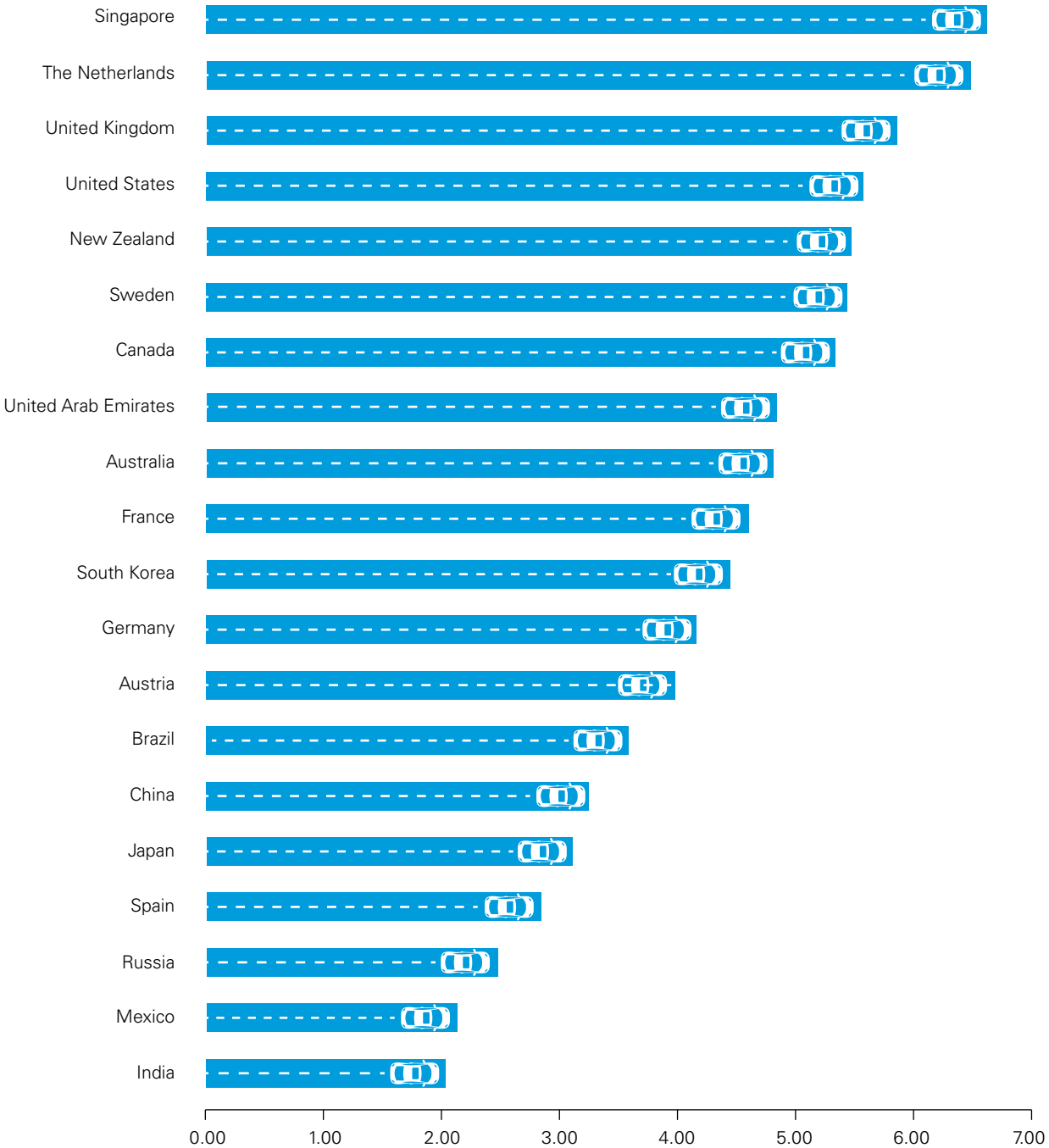


Source: *The State of LTE*, OpenSignal, 2017.

Consumer acceptance

Consumer acceptance scores are based on four variables, all drawing on or using other research. Scores decline gradually from Singapore, the Netherlands and the UK. Germany (12th) and Japan (16th) do significantly worse in this pillar than overall, while Australia does better, reaching ninth. This is the only pillar in which one of the bottom four countries breaks out of an individual pillar's bottom four, with Brazil reaching 14th.

Consumer acceptance pillar: score by country

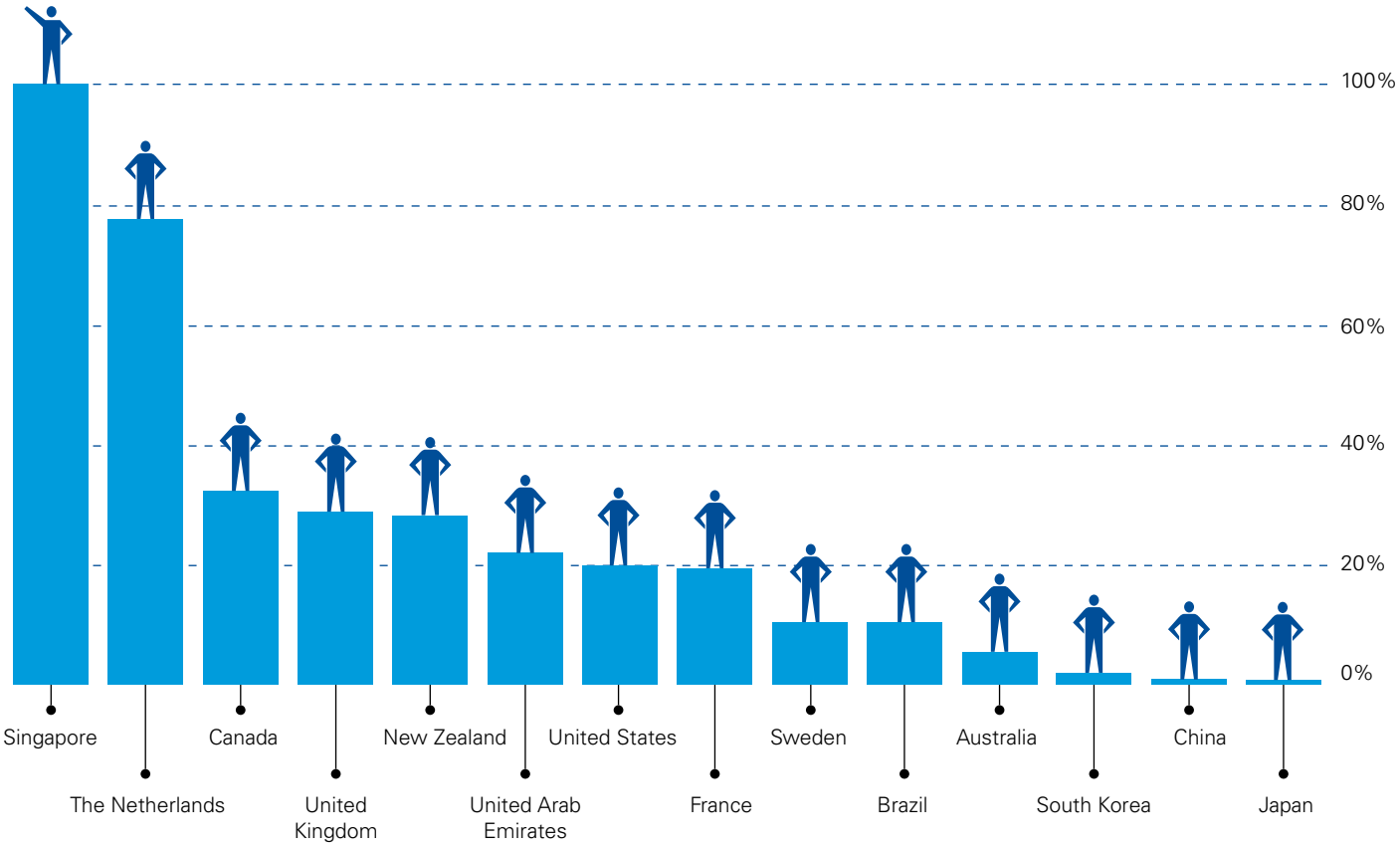


Source: *Autonomous Vehicle Readiness Index*, KPMG International, 2017

This pillar includes a measure of the proportion of the population living in cities hosting AV tests, using data from the Global Atlas of Autonomous Vehicles in Cities. This is led by Singapore, which has hosted a range of AV pilots. The Netherlands also scores highly with Amsterdam, Eindhoven, Haarlem, Rotterdam and Wag eningen running trials, putting 78 percent of people in the same city as a test. The US has 23 ongoing trials, but just a fifth of people live in a test area. Six countries, Austria, Germany, India, Mexico, Russia and Spain, have no current trials and score zero on this variable.

Consumer survey data shows that many of the countries which are least-prepared for AVs have people who are most accepting of the concept: the top three are Brazil, India and China, all of which are in bottom four spots of the overall index. Meanwhile, the Netherlands is near the bottom on this particular variable, and several otherwise well-rated countries are similarly unenthusiastic. This may reflect the poor quality of road transport in the bottom four countries, meaning that the introduction of AVs would allow for massive improvements in personal mobility, while nations with already-good road transport would see relatively fewer benefits.

Proportion of population living in AV test area



Source: *Initiative on cities and autonomous vehicles*, Bloomberg Philanthropies and Aspen Institute

Appendix 2: Methodology

The countries are assessed on 26 different variables within the four pillars. Six are scored for this index by KPMG and Roubini ThoughtLab, which used publicly available information, including media reports, press releases and other material to assess each country's readiness in each area. A further 20 variables use existing research by KPMG and other organizations. Both sources and the data used are provided in this appendix.

The variables under each pillar were combined to arrive at an aggregate score for each pillar. An equal weighting scheme was applied, where all variables were given equal weight in arriving at the overall pillar score. Before the data was combined, it was normalized. Normalization was required as the variables had different measurement units. For the purposes of developing the AVRI Index, the min-max method was used. The min-max method normalized the variables to have an identical range of between zero and one by subtracting the minimum value and dividing by the range of the variable values.

Each pillar has a different number of variables that fall under it. To ensure that the pillar with largest number of variables does not dominate when arriving at the aggregate score, each pillar score was adjusted so that they had the same maximum value. Meaning that each pillar has equal weight in the overall score for each country.

Policy and legislation

The pillar is calculated from seven equally-weighted factors.

AV regulations, AV department within government transportation department, Government investment in AV infrastructure and Number of government funded AV pilots: each of these four factors has been 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 restrictions on testing are scored lower. A similar approach is taken for government investment and number of government-funded AV pilots.

With the AV department variable, governments that spread the responsibility for AVs across a large number of government entities are given lower marks; those which 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.

KPMG Change Readiness government capability: scores are from KPMG International's 2017 *Change Readiness Index*. See kpmg.com/changereadiness.

Effectiveness of law making bodies and **Efficiency of the legal system in challenging regulations:** both from the World Economic Forum's Networked Readiness Index. See http://reports.weforum.org/network-readiness-index/.

Technology and innovation

The pillar is calculated from nine equally-weighted factors.

Industry partnerships research and research and development AV hubs: both of these factors are 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.

AV technology firm headquarters: based on a list of AV-related technology companies built from those published by Vision System Intelligence (http://www.prweb.com/releases/vsi/segmentsautonomousvehicle/prweb13472308.htm) and Comet Labs (https://blog.cometlabs.io/263-self-driving-car-startups-to-watch-8a9976dc62b0). Numbers are scaled by national population.

AV related patents: numbers of patents by country from 'Autonomous car-control mechanism', Patent Insight Pro (http://www.patentinsightpro.com/techreports/0416/Autonomous%20Car-Control%20Mechanism.pdf). Numbers are scaled by national population.

Total investments: number of investments by country derived from 'Gauging investment in self-driving cars', 16 October 2017, Brookings Institute (https://www.brookings.edu/research/gauging-investment-in-self-driving-cars/). Numbers are scaled by national population.

Market share of electric cars: data for most countries from table 10, p51, 'Global EV Outlook 2017', International Energy Agency (https://www.iea.org/publications/freepublications/publication/global-ev-outlook-2017.html). Data for other countries gathered from consultancy and media reports.

Uber market presence: based on the total population of the cities Uber states it serves in each country (https://www.uber.com/cities/) as a proportion of national population. City populations are from the McKinsey Global Institute's Urban World app. In China, a figure of 400 million users of Didi Chuxing, the country's largest ridesharing company, is used (Technode, 5 January 2017, http://technode.com/2017/01/05/didi-accelerates-globalization-with-investment-in-brazilian-uber-rival-99/).

Availability of the latest technology and capacity for innovation: both from the World Economic Forum's Networked Readiness Index. See http://reports.weforum.org/network-readiness-index/.

Infrastructure

The pillar is calculated from six equally-weighted factors.

Density of electric vehicle charging stations: data for most countries from tables 11 and 12, p51, 'Global EV Outlook 2017', International Energy Agency (https://www.iea.org/publications/freepublications/publication/global-ev-outlook-2017.html). Data for other countries gathered from consultancy and media reports. Scaled by length of paved roads in each country from the CIA World Factbook (https://www.cia.gov/library/publications/resources/the-world-factbook/fields/2085.html).

GSMA Global Connectivity Index for infrastructure: from the GSMA. See http://www.mobileconnectivityindex.com/#year=2016&indicatorType=enabler&index=infrastructure&dimension=&indicator=

4G coverage: from 'The State of LTE', OpenSignal, June 2017 (https://opensignal.com/reports/2017/06/state-of-lte).

Quality of roads: from the World Economic Forum's Global Competiveness Index (http://www3.weforum.org/docs/GCR2017-2018/05FullReport/TheGlobalCompetitivenessReport2017%E2%80%932018.pdf).

LPI infrastructure score: from the World Bank's Logistic Performance Index (https://lpi.worldbank.org/).

KPMG's *Change Readiness Index* technology infrastructure and infrastructure: see kpmg.com/changereadiness.

Consumer acceptance

The pillar is calculated from four equally-weighted factors.

Population living in test areas: data on cities with AV testing from 'Initiative on cities and autonomous vehicles', Bloomberg Philanthropies and Aspen Institute (http://avsincities.bloomberg.org/). City populations are from the McKinsey Global Institute's Urban World app.

Consumer survey data on AV acceptance: data for China, France, Germany, India, Japan, Netherlands, Singapore, UAE, UK and US from a 2015 survey carried out by Boston Consulting Group for the World Economic Forum (http://www3.weforum.org/docs/WEF_Press%20release.pdf). Data for Canada, Russia and Brazil from 2013 research carried out for Cisco (https://inhabitat.com/half-of-the-worlds-consumers-trust-autonomous-cars-according-to-a-new-study/). Data for Australia and Spain from national research in those countries. For countries where no survey data is available, data for a comparable country or the global average is used.

KPMG's *Change Readiness Index* people and civil society technology use: see kpmg.com/changereadiness.

Technology readiness: from the World Economic Forum's Global Competiveness Index (http://www3.weforum.org/docs/GCR2017-2018/05FullReport/TheGlobalCompetitivenessReport2017%E2%80%932018.pdf).

Appendix 3: Additional scoring tables

Pillar 1: Policy and legislation

	AV regulations	AV department within government transportation department	Government investment in AV infrastructure	Number of government funded AV pilots	KPMG Change Readiness government capability	WEF NRI Effectiveness of law-making bodies	WEF NRI Efficiency of the legal system in challenging regulations
Australia	5.0	5.0	5.0	4.0	0.710	4.822	4.654
Austria	5.0	6.5	6.5	6.0	0.704	4.177	4.718
Brazil	2.0	1.0	1.0	1.0	0.451	2.398	2.937
Canada	5.0	5.0	6.5	7.0	0.694	5.254	5.040
China	4.0	4.5	4.0	4.0	0.594	4.192	3.492
France	5.5	5.0	4.0	6.0	0.638	4.833	4.391
Germany	5.5	6.0	6.0	6.0	0.755	5.048	5.187
India	0.0	0.0	0.0	0.0	0.537	4.026	4.086
Japan	3.0	4.5	5.0	6.0	0.661	5.441	4.584
Mexico	1.0	1.0	1.0	1.0	0.488	3.178	3.012
New Zealand	6.5	6.5	6.0	5.0	0.781	5.837	5.484
Russia	4.0	1.0	4.0	2.0	0.503	3.584	2.915
Singapore	7.0	7.0	5.0	7.0	0.841	6.299	5.194
South Korea	6.0	6.0	7.0	7.0	0.600	3.242	3.386
Spain	6.0	5.0	5.0	4.0	0.584	4.056	3.507
Sweden	5.0	5.0	4.0	5.0	0.829	5.460	5.081
The Netherlands	7.0	5.0	7.0	6.5	0.750	5.251	5.463
United Arab Emirates	6.0	6.5	5.0	5.0	0.837	5.316	4.707
United Kingdom	6.0	6.0	6.0	6.0	0.714	5.701	5.292
United States	6.0	5.0	5.5	6.5	0.657	4.042	4.792

Pillar 2: Technology and innovation

	Industry partnerships	Research and development AV Hubs	AV technology firm headquarters per million people	AV related patents per million people	Total investments per million people	IEA Market share of electric cars	Uber market presence	WEF NRI Availability of the latest technology	WEF NRI Capacity for innovation
Australia	4.0	4.0	0.084	1.387	0.000	0.10%	75%	5.909	4.814
Austria	5.0	6.0	0.115	0.230	0.000	0.16%	45%	6.088	5.401
Brazil	2.0	1.0	0.000	0.000	0.000	0.00%	56%	4.469	3.818
Canada	7.0	6.0	0.417	0.223	0.111	0.59%	50%	6.244	4.879
China	5.0	6.0	0.009	0.603	0.004	1.37%	29%	4.301	4.196
France	6.0	5.5	0.109	1.707	0.078	1.46%	36%	6.048	5.067
Germany	7.0	7.0	0.269	17.526	0.220	0.73%	35%	6.223	5.640
India	2.0	2.0	0.008	0.004	0.000	0.02%	14%	4.025	4.178
Japan	6.0	5.0	0.109	24.138	0.063	0.59%	32%	6.157	5.266
Mexico	1.0	1.0	0.000	0.008	0.000	1.11%	46%	4.954	3.972
New Zealand	5.0	4.0	0.000	0.000	0.000	2.00%	44%	5.895	5.263
Russia	2.0	2.0	0.000	0.007	0.000	0.00%	23%	4.223	3.767
Singapore	6.0	6.5	0.000	0.000	0.000	0.07%	100%	6.202	5.140
South Korea	7.0	7.0	0.099	14.014	0.059	0.34%	20%	5.641	4.823
Spain	4.0	4.0	0.000	0.108	0.065	0.40%	28%	5.520	4.092
Sweden	5.0	5.0	0.512	8.808	0.205	3.41%	66%	6.482	5.687
The Netherlands	5.0	6.0	0.413	0.236	0.059	6.39%	43%	6.300	5.246
United Arab Emirates	4.0	4.0	0.000	0.000	0.000	1.11%	31%	6.327	4.693
United Kingdom	6.0	6.0	0.291	2.752	0.153	1.41%	52%	6.477	5.383
United States	7.0	7.0	0.509	2.860	0.275	0.91%	75%	6.544	5.944

Pillar 3: Infrastructure

	IEA Density of electric vehicle charging stations per 100km	GSMA Global Connectivity Index for infrastructure	OpenSignal 4G coverage	WEF GCI Quality of roads	World Bank LPI infrastructure	KPMG Change Readiness technology infrastructure
Australia	0.134	83.320	79%	4.814	3.820	0.750
Austria	0.937	76.240	73%	5.954	4.080	0.730
Brazil	0.072	55.750	55%	3.115	3.110	0.600
Canada	1.014	75.380	81%	5.379	4.140	0.560
China	3.491	63.510	83%	4.579	3.750	0.470
France	1.540	73.660	58%	6.050	4.010	0.690
Germany	2.783	77.500	59%	5.510	4.440	0.650
India	0.008	39.990	82%	4.311	3.340	0.350
Japan	2.342	73.840	93%	6.107	4.100	0.750
Mexico	0.509	55.670	69%	4.373	2.890	0.440
New Zealand	0.081	81.260	58%	4.662	3.550	0.690
Russia	0.070	51.560	59%	2.897	2.430	0.720
Singapore	2.161	81.140	82%	6.346	4.200	0.800
South Korea	2.001	78.260	96%	5.555	3.790	0.750
Spain	0.120	71.530	72%	5.496	3.720	0.650
Sweden	1.954	78.740	84%	5.481	4.270	0.690
The Netherlands	19.255	77.440	86%	6.136	4.290	0.750
United Arab Emirates	2.451	68.140	75%	6.367	4.070	0.860
United Kingdom	3.108	74.760	66%	5.108	4.210	0.750
United States	0.940	69.600	87%	5.734	4.150	0.710

Pillar 4: Social acceptance

	Population living in test areas	Consumer survey data on AV acceptance	KPMG Change Readiness people and civil society technology use	WEF GCI technology readiness
Australia	5.5%	0.500	0.870	5.718
Austria	0.0%	0.440	0.680	5.971
Brazil	10.3%	0.950	0.310	4.568
Canada	32.2%	0.520	0.800	5.880
China	0.9%	0.750	0.520	4.183
France	19.4%	0.580	0.620	5.899
Germany	0.0%	0.440	0.690	6.169
India	0.0%	0.850	0.310	3.116
Japan	0.8%	0.360	0.500	6.006
Mexico	0.0%	0.560	0.390	4.209
New Zealand	28.2%	0.500	0.840	6.092
Russia	0.0%	0.560	0.420	4.548
Singapore	100.0%	0.620	0.620	6.089
South Korea	2.0%	0.620	0.690	5.648
Spain	0.0%	0.280	0.560	5.676
Sweden	10.4%	0.580	0.830	6.302
The Netherlands	77.5%	0.410	0.860	6.344
United Arab Emirates	21.9%	0.700	0.580	5.811
United Kingdom	28.8%	0.490	0.910	6.329
United States	19.8%	0.520	0.880	6.235

Authors and partners

Richard Threlfall is the Global Head of Infrastructure for KPMG International. He has over 20 years' experience in the financing and structuring of infrastructure projects. His particular focus is advising on transactions for public and private clients in the transport and utility sectors. Before joining KPMG, Richard was employed as a civil servant at the UK Department for Transport where he held positions in the road, rail and aviation directorates. Between 1996 and 1998 he was Private Secretary to the Secretary of State for Transport and the Deputy Prime Minister. He also chairs The Infrastructure Forum, which is an independent think-tank that brings together organizations with involvement in UK infrastructure from public, private and regulatory perspectives.

Roubini ThoughtLab, a business venture with Econsult Solutions, a leading economics consultancy with direct links to academia, provides innovative economic analysis to help corporate, financial and government leaders cope with transformative change. By applying analytical tools, qualitative research, and expert opinions, the firm provides actionable insights into industry, economic, regulatory and technology trends and their impact on the world.

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KPMG's Global Public Sector Transport network works with public transport authorities to embrace emerging technologies to help increase capacity, optimize asset lifecycle and leverage existing data. We help governments and transport providers to understand and shape the future of public transport, while supporting them in improving the experiences of customers today.

We understand that our clients need to enhance their performance while cutting costs and using existing assets, and support them through realizing the value of their land and increasing ancillary revenues, such as from digital advertising. We also support them in maximizing opportunities from disruptive technologies including EVs and AVs, mobility as a service (MaaS), smart assets and transport systems, data and analytics.

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Further reading

In case you missed them, you can download our previous papers related to the future of AVs as well as the automotive and transportation industry.

Islands of autonomy: How autonomous vehicles will emerge in cities around the world

December 2017

Across the world, a trillion-dollar market is swiftly developing around a new and disruptive transportation mode: driverless vehicles coupled with mobility services. The adoption of the new transportation mode will not be immediate and everywhere. KPMG examines the various 'islands of autonomy' and their impact on cities, transportation systems, the automotive market and consumer behavior.

Reimagine Places: Mobility as a Service

August 2017

The Mobility as a Service (MaaS) Requirements Index: A guide for determining the required regulatory, governance, commercial, and technological environment to facilitate policy and customer-optimized mobility services.

Autonomous Vehicles: the public policy imperatives

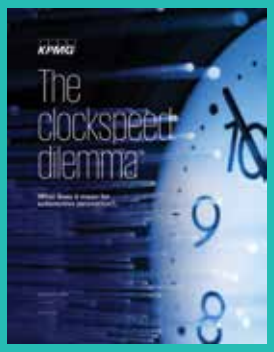
December 2016

Explores the key issues where driverless cars will have a significant impact, helping authorities to start to envision a blueprint for the design and implementation of an AV-powered community of the future.

I see. I think. I drive. (I learn): how deep learning in revolutionizing the way we interact with our cars

November 2016

Deep learning, an advance from artificial intelligence and dynamic way of computerized decision making is driving significant change for autonomous cars and for the automotive and transportation industry. Deep learning is critical enable of building a self-driving vehicle that can operate without human intervention. KPMG examines the direct impacts of deep learning and how it will revolutionize the nature of doing business.



The clockspeed dilemma: What does it mean for automotive innovation?

November 2015

The convergence of the consumer and automotive technologies and the rise of mobility services, and the development of autonomous vehicles are revolutionizing the automotive industry and the way we live our lives. There will be profound impacts on vehicles miles traveled, vehicles sales, car ownership models, energy demand and infrastructure. KPMG examines how the automotive industry must innovative to survive.

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