Europe 5G Readiness Index

Assessing Europe's readiness to deploy 5G

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Introduction

The wait is over. 5G is here. A lot has been said and written in the past years regarding the new generation of mobile technologies which is now coming to life across the world. For some companies 5G is their last chance to boost their revenues and become relevant in the marketplace again, while others see it as an unnecessary cash-burning upgrade for which there is no clear value proposition to justify the additional investment required. 5G has become the new arms race between the different nations, which are desperately trying to claim leadership in 5G for their own reasons. Countries which have traditionally been pioneers in technology development and adoption continue to lead the 'race to 5G', while nations which have traditionally been technology buyers have started investing in the new technology, also wanting a piece of the 5G cake. All in all, each country's 5G readiness depends on several economic, operational and social factors.

Recognising this gap, we have constructed Europe 5G Readiness Index which allows users to compare all European countries between them on how ready they are to launch 5G. This Index presents an overall readiness score for each country which comprises 6 factor categories with 35 criteria in total within those categories. Scores at all levels of the Index can be used to compare different markets between them on a like-for-like basis.

The results of our analysis show that there is a significant gap between Western and Eastern Europe, with countries in the former being, on average, more ready to introduce 5G. Also, there appears to be a high correlation between a country's 5G readiness score and its geographic position, which creates 3 'clusters' of countries across Europe. Not surprisingly, a country's welfare, as measured by GDP per capita, also seems to correlate positively with its 5G readiness score.

More details regarding the methodology and assumptions used to construct the Index can be found in the Europe 5G Readiness Index: Methodology document. For press inquiries, email info@incites.com.

01 Index Results

Table 1

5G Readiness Index – Equal weights

Total Rank	Country Name	Total Score	Infrastructure and Technology		Regulation and Policy		Innovation Landscape		Human Capital		Country Profile		Demand	
			Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
1	Finland	71.8	63.4	5	71.7	5	72.2	2	78.5	1	83.4	4	61.3	7
2	Sweden	69.8	66.7	1	69.0	7	73.2	1	61.1	14	83.0	6	65.7	3
3	Switzerland	69.6	56.6	11	73.3	1	70.2	3	70.9	2	83.6	3	62.8	5
4	Netherlands	68.2	55.7	14	73.1	2	65.7	6	70.9	3	83.1	5	60.5	9
5	Denmark	67.8	59.3	10	64.8	12	65.9	5	66.8	6	78.6	16	71.8	1
6	Norway	67.8	61.0	8	72.7	3	63.6	9	67.7	4	83.8	2	57.8	12
7	Germany	66.9	65.6	2	67.8	8	69.1	4	66.6	7	81.8	8	50.3	20
8	United Kingdom	66.8	60.4	9	72.6	4	64.2	8	60.3	15	81.5	10	62.0	6
9	Iceland	65.2	53.4	16	65.1	10	59.8	12	63.9	11	80.6	12	68.4	2
10	Luxembourg	64.3	56.1	12	70.1	6	63.1	10	49.1	29	88.3	1	59.5	10
11	France	62.7	64.8	4	59.8	14	59.0	14	61.5	13	80.2	13	50.9	19
12	Ireland	62.5	46.5	23	65.0	11	59.3	13	66.9	5	82.4	7	55.0	15
13	Estonia	62.0	51.7	19	65.4	9	52.0	16	62.4	12	81.7	9	58.9	11
14	Austria	61.6	50.3	20	53.2	17	62.4	11	63.9	10	78.9	15	60.8	8
15	Belgium	61.2	43.4	28	58.4	15	64.4	7	66.5	8	79.3	14	55.2	14
16	Portugal	58.8	61.3	7	48.8	21	52.7	15	57.4	19	80.8	11	51.8	18
17	Spain	57.6	65.2	3	47.2	22	46.9	20	57.5	18	75.9	18	52.6	17
18	Lithuania	56.7	52.7	18	49.9	20	48.5	19	55.6	22	76.1	17	57.3	13
19	Slovenia	53.9	47.8	22	44.5	24	51.6	17	59.6	17	73.0	20	46.8	24
20	Latvia	53.3	55.9	13	44.2	25	39.7	28	49.5	28	67.6	31	63.0	4
21	Czech Republic	53.0	53.2	17	43.4	26	49.3	18	55.5	23	71.3	21	45.5	25
22	Russia	52.1	53.8	15	46.4	23	40.9	27	56.9	20	67.0	33	47.5	22
23	Italy	51.7	61.8	6	34.9	34	42.9	24	55.7	21	70.3	24	44.7	26
24	Azerbaijan	51.5	36.1	35	62.2	13	44.6	22	47.9	31	75.5	19	42.8	29
25	Poland	49.9	44.8	24	34.0	35	41.2	26	54.7	24	71.0	23	53.8	16
26	Slovakia	48.8	44.3	26	37.5	32	46.7	21	45.1	34	71.2	22	48.0	21
27	Hungary	48.4	42.4	30	42.7	27	44.6	23	43.2	35	70.3	25	47.0	23
28	Cyprus	48.3	41.4	31	52.2	18	35.5	32	53.6	25	67.9	30	39.3	35
29	Greece	47.4	42.5	29	33.8	36	36.2	29	65.4	9	64.3	36	42.5	31
30	Romania	47.3	49.7	21	39.0	31	33.8	34	48.9	30	69.7	27	42.7	30
31	Croatia	46.3	43.4	27	33.7	37	33.4	35	53.5	26	70.1	26	43.8	27
32	Bulgaria	45.6	38.2	33	35.7	33	41.9	25	46.4	33	68.4	28	43.2	28
33	Serbia	45.4	38.6	32	42.2	29	36.0	31	51.4	27	67.0	34	37.0	36
34	Albania	45.1	30.3	36	50.6	19	36.1	30	46.9	32	67.1	32	39.8	34
35	Georgia	45.0	37.0	34	56.2	16	31.5	36	37.5	37	67.9	29	40.1	33
36	Moldova	43.8	44.5	25	41.4	30	29.9	37	39.8	36	66.1	35	41.1	32
37	Ukraine	42.7	26.4	38	42.5	28	34.3	33	59.6	16	62.8	37	30.5	38
38	Bosnia & Herzegovina	35.2	27.2	37	26.0	38	28.8	38	34.1	38	59.9	38	35.0	37

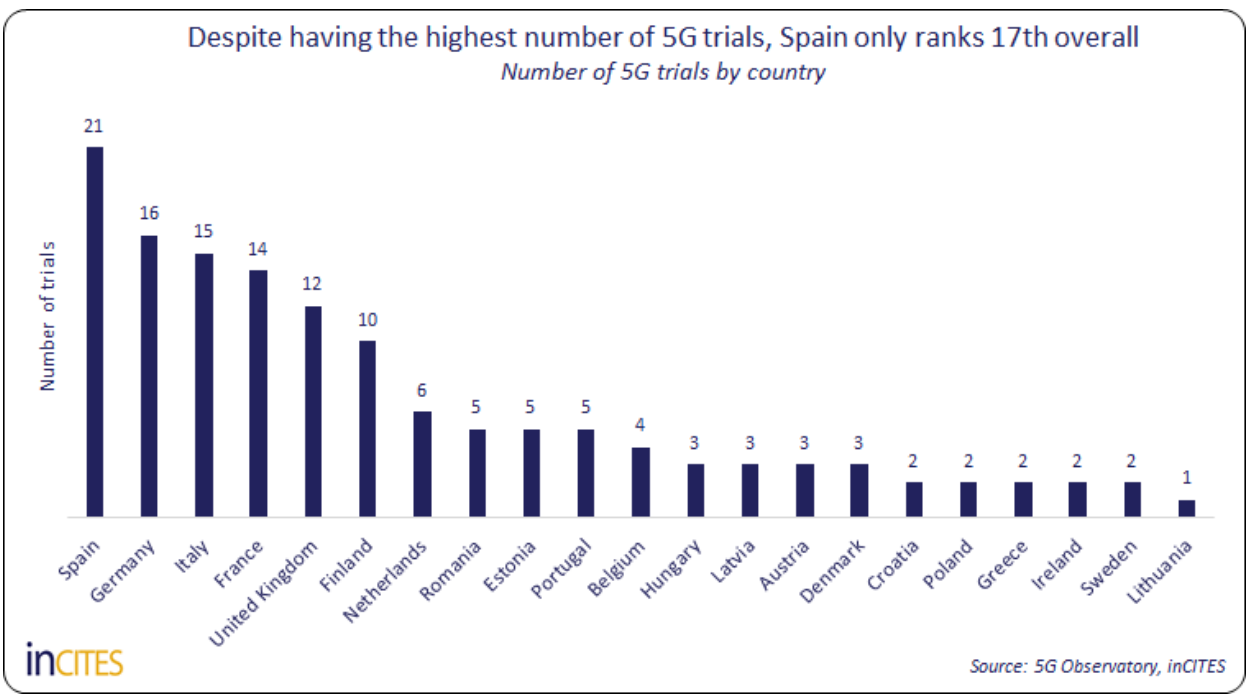
02 Highlights by Geography

2.1 Western Europe

As part of the European Commission's Digital Agenda for Europe targets, at least one major city in every Member State should have a commercial 5G network by 2020. The majority of the countries are already running trials across their territories, while others are making preparations to launch their pilots in 2019. Although running pilots is key in preparing for 5G, it is only one of the aspects that needs to be in place in order to succeed in the era of the next generation of mobile networks. This is further highlighted by the fact that none of top-6 countries of the Index score within the top-6 spots in the *5G pilots* criterion. What is key, however, in preparing for 5G, is to have a well-forged framework that will facilitate the creation of an ecosystem which will adopt and further develop the new technology. Italy, for instance, is 2nd in the *5G pilots* criterion, running 15 pilots across the country, though it only ranks 23rd in the overall rank, due to it scoring low in the other categories.

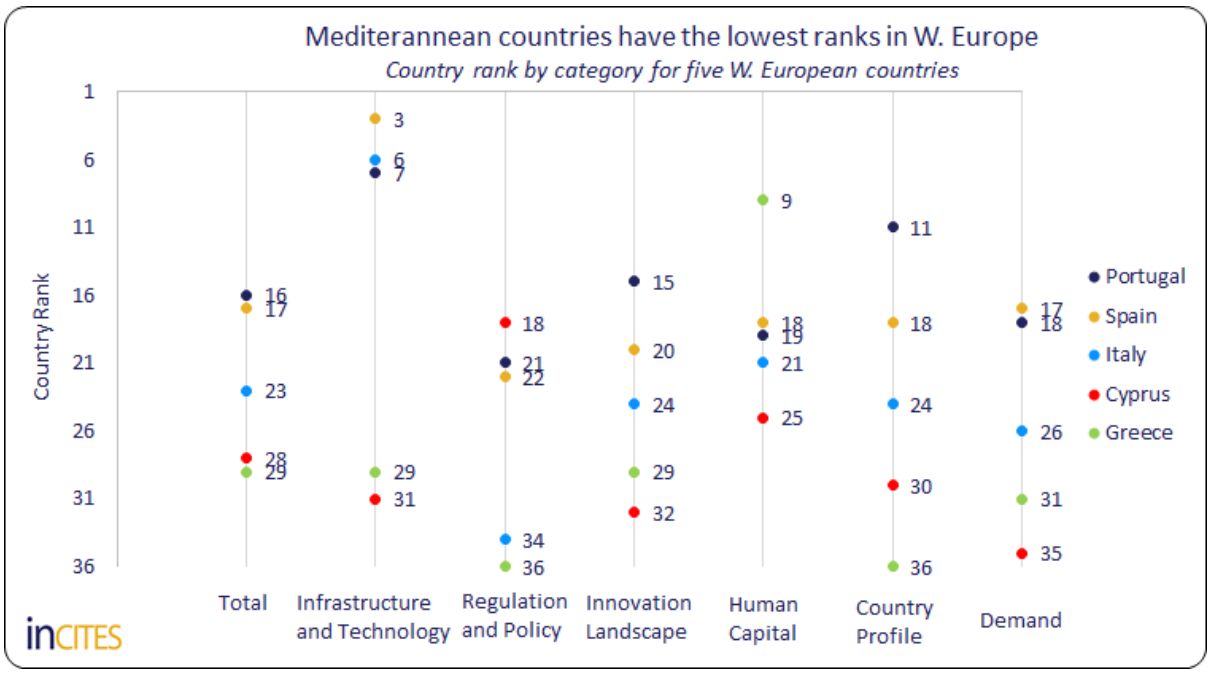
Table 2 Overall & 5G pilots ranking of top-6 countries

Country name	Overall Rank	5G pilots rank
Finland	1	7
Sweden	2	22
Switzerland	3	8
Netherlands	4	8
Denmark	5	16
Norway	6	12



Overall, Western European countries capture the first 17 places of the *Europe 5G Readiness Index* likely due to the coordinated mandate of the European Commission in conjunction with the high level of competition that exists in those markets which forces operators to always adopt the latest technologies. In fact, 8 out of the top 10 ranked countries got the highest possible score in the level of *competition criterion*.

All five Nordic countries, namely, Denmark, Finland, Iceland, Norway and Sweden, rank within the top-10 countries, while four of them are within the top-6. This is no surprise given that the Nordics have traditionally been at the forefront of technology development. In the 5G era, specifically, all five nations' digitalisation Ministers (plus Lithuania which joined them later) signed a Letter of Intent in May 2018, in which they outlined their intention to cooperate in the development and adoption of 5G.



Another interesting finding from this study shows that some Southern European countries, such as Portugal, Spain, Italy, Cyprus and Greece, rank last between the Western European markets. And although Portugal, Spain and Italy score high at the *Infrastructure and Technology* criterion, it is the rest of the criteria that drag them to these low levels versus their peers. More specifically,

Regulation and Policy seems to be the criterion in which these countries rank in the lowest positions, on average, versus the rest of the criteria. This could likely be attributed to the inflexible legal system that some of these countries have, which will potentially hinder them from passing the necessary regulatory reforms in due time to facilitate the deployment of 5G networks.

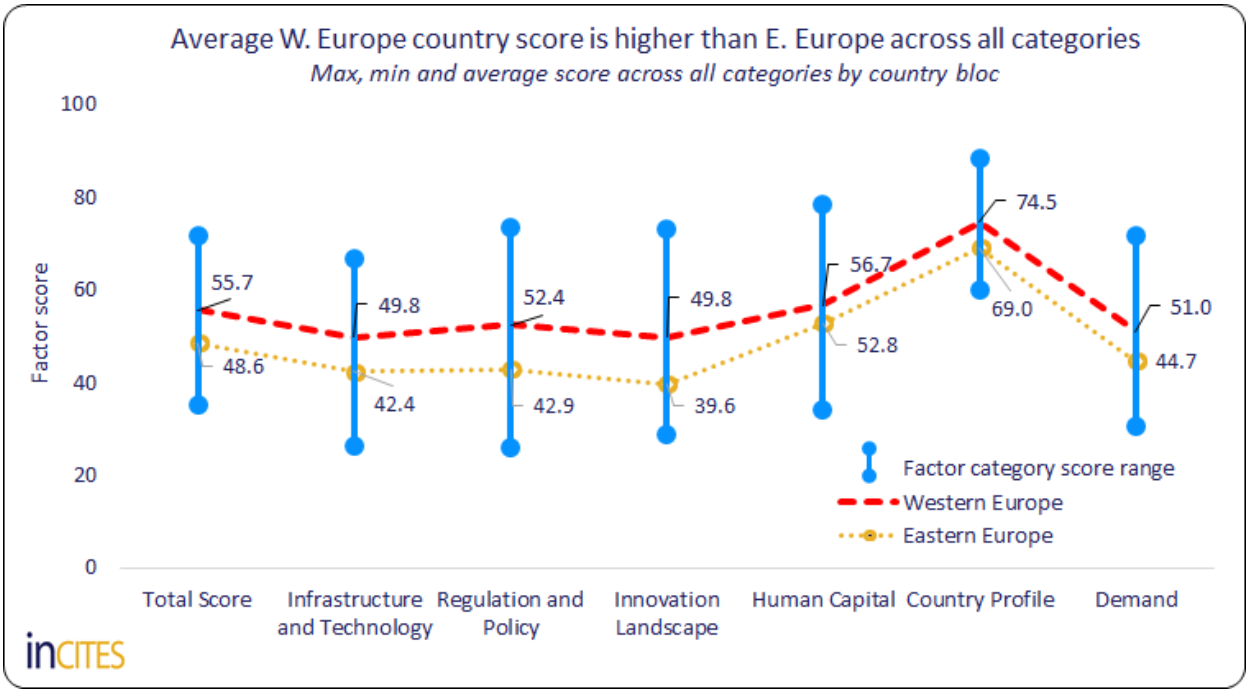
Benelux countries show a mixed picture with Netherlands ranking 4th, Luxembourg ranking 10th and Belgium being in the 15th position. Netherlands ranks 2nd overall in the *Regulation and Policy* and 3rd in the *Human Capital* categories, highlighting the state's willingness to intervene in the regulation to facilitate the smooth development of 5G networks and the enable the availability of tech-savvy skilled workers and researchers in the country. Luxembourg, in turn, ranks 1st in the *Country Profile* category, due to the *importance of ICTs to the Government's vision* while it scores quite low in the *Human Capital* category (29th). Belgium scores well in the *Innovation Landscape* (7th) and *Human Ca*pital (8th) categories, while it ranks 28th in the *Infrastructure and Technology* category, likely due to its limited fiber coverage, which is set to improve over the following years as operators have outlined plans for fiber deployment across the country.

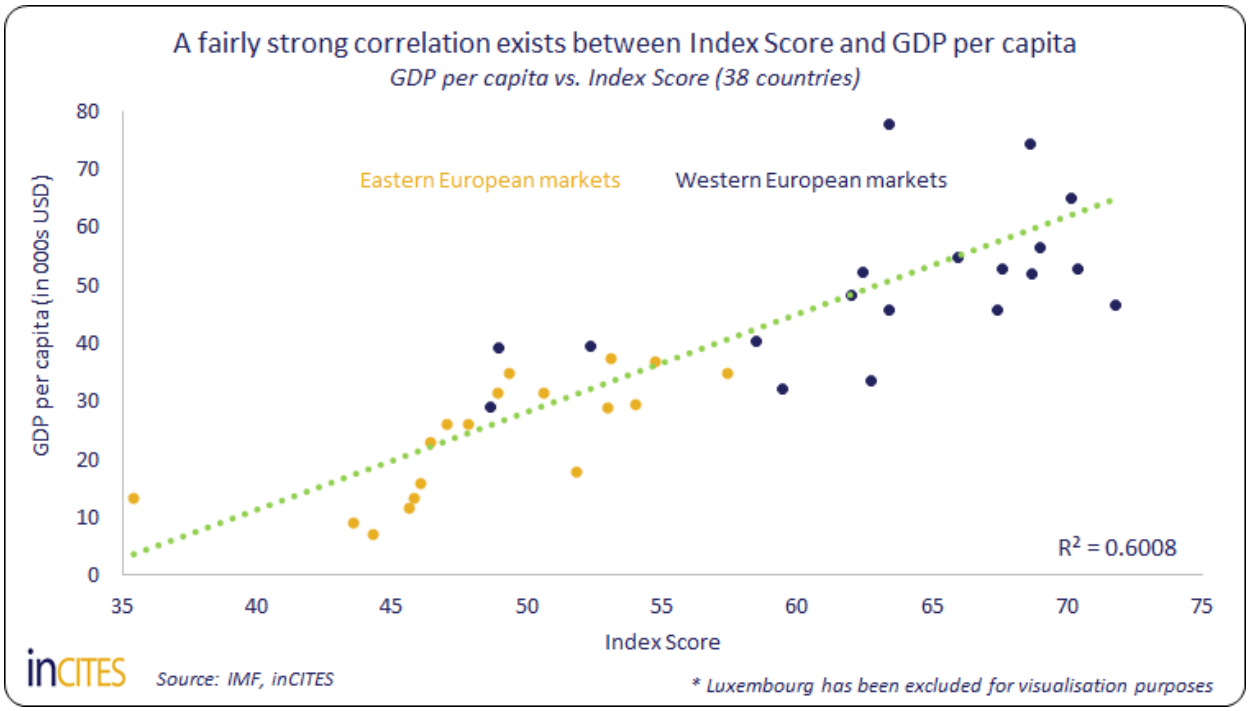
Interesting Data Points

- Norway and Sweden launched 4G concurrently in Oslo and Stockholm, respectively, in 2009 and although Sweden currently ranks 2nd in the overall score, Norway appears to be lagging behind its neighbour in some of the categories, such as *Innovation* (9th vs. 1st) and *Demand* (12th vs. 3rd), overall capturing the 6th spot.
- Spain ranks 2nd in the *5G pilots* criterion, with 21 pilot projects, but overall it is in the 17th position, as it ranks 17th or lower in 5 out of the 6 main categories.
- The average score for EU countries stands at 57.5, while for Non-EU markets at 51.2. The overall country average is 55.7.
- A correlation analysis between all examined criteria and the countries' land area (km^2) was conducted to identify whether country size has any role to play in a country's 5G readiness. No significant correlation was identified to exist between country size and any one criterion. Hence, our initial hypothesis was rejected.

2.2 Eastern Europe

Eastern European markets appear to be not as ready as their Western European counterparts to deploy and adopt 5G, since the highest ranked Eastern European market (Lithuania) is in the 17th position. This is likely due to the absence of a single entity that sets targets for the digital alignment of the different states and helps formulate their digital strategies, as is the case with the European Commission bodies. One interesting data point highlighting the digital divide between the Eastern and Western European countries is that except Latvia's rank as 4th in the Demand factor category, no Eastern European country ranks higher than 13th in any of the six factor categories. In fact, the average score of Western Europe is higher than Eastern Europe across all factor categories, further highlighting Western Europe's progress in 5G.





This score gap between Western and Eastern European markets raises the question on whether a relationship between a country's economic situation and its score exists. The Figure below shows that a strong correlation (~60%) exists between GDP per capita and Index Score, which could imply that economic status is likely one of the reasons that explain the current digital divide between Western and Eastern Europe.

To highlight this even further, the correlation between the two variables increases to R^2=71% if one excludes one outlier country from each variable, namely Luxembourg (GDP per capita at $108k) and Bosnia and Herzegovina (Index Score of 35.4).

Interesting Data Points

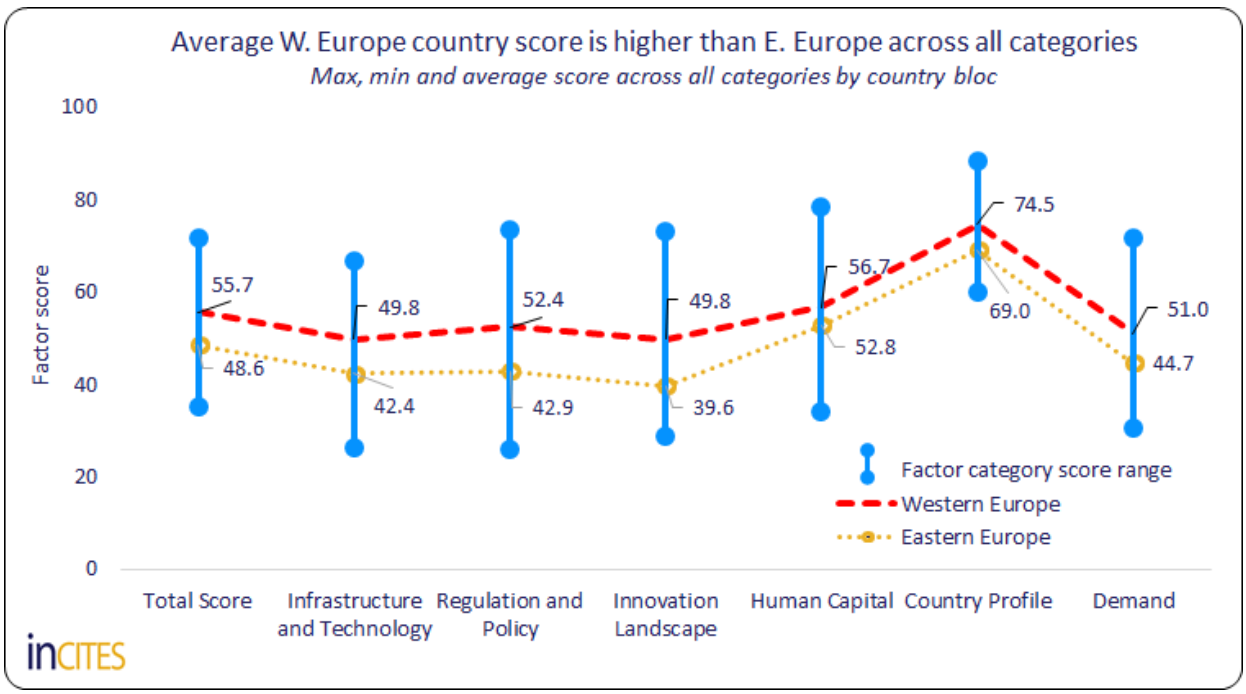
- The Eastern European market with the highest rank if one excludes the markets that belong to the EU, is Russia in the 22nd position.
- Bosnia and Herzegovina ranks last (38th) or penultimate (37th) in all six factor categories and is the only market that ranks below the 30th position in all categories.
- Five Eastern European countries rank above Italy, namely, Lithuania, Slovenia, Latvia, Czech Republic and Russia.
- Only one Eastern European market (Lithuania) scores above the total average score (56.7 vs. 55.7).
- The highest-ranking Balkan country is Greece, on the 29th position, while the rest of the Balkan countries are below the 30th position.

2.3 Baltics

Baltic countries stand in the middle of the table at the 13th (Estonia), 18th (Lithuania) and 20th (Latvia) position, respectively. Estonia ranks 9th in both the *Regulation and Policy* and *Country Profile* categories likely due to the government's eagerness to promote e-governance initiatives (Estonia ranks 3rd in the *Importance of ICTs to government vision* factor).

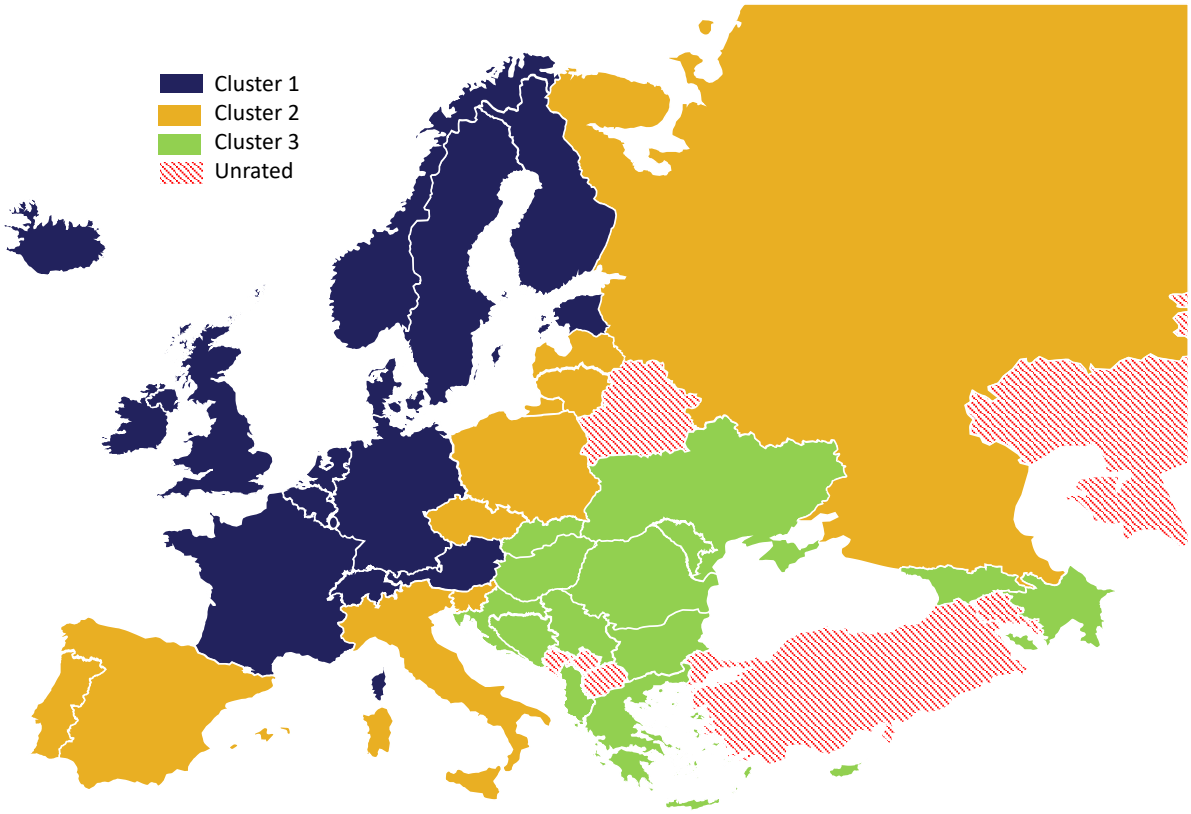
According to the e-Estonia website, Estonia is probably the only country in the world where 99% of the public services are available online 24/7. Latvia and Lithuania, in turn, score 2nd and 3rd, respectively in fiber coverage and within the top-8 countries in *mobile data traffic* but fail to score high in the *Human Capital* and *Country Profile* categories.

Countries that have traditionally been pioneers in technology development and adoption lead the 5G race in Europe. Due to their geographic proximity with Nordic countries, Baltic countries are cooperating heavily with them in order to facilitate the swift and smooth transition to 5G networks.



2.4 Clustering Analysis

Clustering analysis was performed to identify whether the analysed markets can be grouped into clusters with similar characteristics with geographical correlation being atop of the hypotheses list. The analysis revealed three main country groups, with unequal distribution between them. More specifically, the first cluster includes 15 countries, the second 9 countries and the third 14 countries.



Interesting Data Points

- The first cluster includes the top-15 countries as per the Index ranking. All the countries in the first cluster belong to W. Europe and they are located in the north-west part of Europe.
- The average GDP per capita for the three clusters is $57.8k, $34.6k and $21.4k, respectively and 14 out of 15 countries within the first cluster are also the top-14 countries by GDP per capita in W. Europe. This further highlights the relationship between ranking and economic status.
- The second cluster comprises nine countries, 3 from W. Europe and 6 from E. Europe, while all countries except Russia are part of the EU. This cluster's number of countries, highlights that, essentially, there is polarisation between the analysed countries, as the majority of them falls within the two side clusters.
- The third cluster comprises 14 countries, of which 12 are from E. Europe and 2 are from W. Europe. This cluster includes countries from the South-East part of Europe, including all the Balkan countries that were part of the study.

Table 3

Overall and 5G pilots ranking of top-6 countries

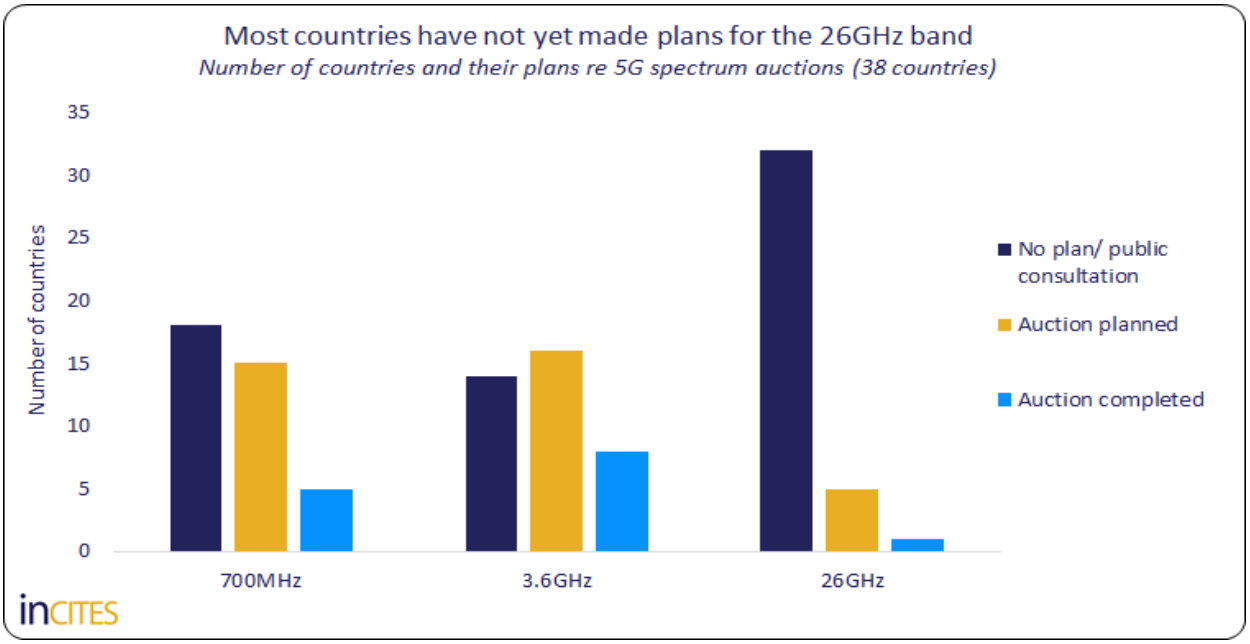
Country name	Cluster	Country Rank	Region	GDP per capita
Finland	1	1	Western Europe	46.559
Sweden	1	2	Western Europe	52.719
Switzerland	1	3	Western Europe	64.988
Netherlands	1	4	Western Europe	56.571
Denmark	1	5	Western Europe	51.841
Norway	1	6	Western Europe	74.318
Germany	1	7	Western Europe	52.897
United Kingdom	1	8	Western Europe	45.643
Iceland	1	9	Western Europe	54.753
Luxembourg	1	10	Western Europe	109.199
Ireland	1	11	Western Europe	77.670
France	1	12	Western Europe	45.601
Estonia	1	13	Western Europe	33.553
Austria	1	14	Western Europe	52.224
Belgium	1	15	Western Europe	48.179
Portugal	2	16	Western Europe	32.023
Spain	2	17	Western Europe	40.371
Lithuania	2	18	Eastern Europe	34.829
Slovenia	2	19	Eastern Europe	36.826
Latvia	2	20	Eastern Europe	29.488
Czech Republic	2	21	Eastern Europe	37.423
Russia	2	22	Eastern Europe	29.032
Italy	2	23	Western Europe	39.472
Poland	2	25	Eastern Europe	31.647
Azerbaijan	3	24	Eastern Europe	17.955
Slovakia	3	26	Eastern Europe	35.099
Cyprus	3	27	Western Europe	39.302
Hungary	3	28	Eastern Europe	31.561
Greece	3	29	Western Europe	29.112
Romania	3	30	Eastern Europe	26.176
Croatia	3	31	Eastern Europe	26.216
Bulgaria	3	32	Eastern Europe	23.207
Serbia	3	33	Eastern Europe	16.090
Albania	3	34	Eastern Europe	13.330
Georgia	3	35	Eastern Europe	11.600
Moldova	3	36	Eastern Europe	7.104
Ukraine	3	37	Eastern Europe	9.182
Bosnia and Herzegovina	3	38	Eastern Europe	13.513

03 Highlights by Factor Category

3.1 Infrastructure and Technology

This category includes factors that relate to existing fixed and mobile infrastructure that will be used in 5G networks as well as preparatory steps towards deploying the new technology, such as spectrum auctions and 5G trials. In the early years of 5G, operators are expected to deploy Non-Standalone (NSA) 5G networks, which will rely heavily on existing 4G infrastructure to operate.

In a next stage, they will upgrade their network according to Standalone (SA) 5G standards, which will be relying solely on 5G infrastructure. Fiber will play a key role in the development of 5G networks both on the core side, but most importantly in backhauling for small cells. The large amount of data expected to be transferred through small cells, requires very high capacity backhauling, which cannot be supported by technologies based on copper.



5G in the low and mid bands will enable a host of innovative services in the early years, while mmWave band deployments are expected to happen later.

Overall, the least variability between the countries across all criteria was observed in the *4G availability* criterion, which likely implies that as technology matures, it is easier for laggard countries to close the gap with the pioneer countries more easily. This is likely due to equipment commoditisation and the economies of scale which result in significant price benefits for laggards. The largest variability is seen in the 5G spectrum auctions criterion where several countries either have no plans for 5G spectrum auctions yet or they are in the process of conducting public consultations.

Interesting Data Points

- Western European markets capture the top-12 position in this category with an average score of 56.2 versus 42.2 for Eastern European markets. The average score for this category stands at 49.6.
- Although Sweden ranks 1st in this category overall and in both the *Internet BW per user* and *4G launch date* criteria, it only captures the 22nd position in the *5G Pilots* criterion.
- Ukraine stands in the last position in this category, mainly due to its late launch of 4G[1] (July 2018) as well as its last position in the *time to get electricity* criterion.
- Netherlands ranks 14th in this category, despite being 4th in the overall ranking due to low scores in the *fiber coverage* and *time to get electricity* criteria. Netherland's score in the former should not be interpreted as a country weakness in fixed networks as such, as Netherlands has traditionally been a cable market, with the 3rd highest population coverage in the EU at 95.1% (2017). However, for the purpose of the *Europe 5G Readiness Index*, only fiber network coverage is taken into consideration.

[2]Bosnia and Herzegovina still have no 4G network yet. As part of the skewness and kurtosis control exercise, Bosnia's score for the 4G availability and 4G launch date criteria was set equal to Ukraine.

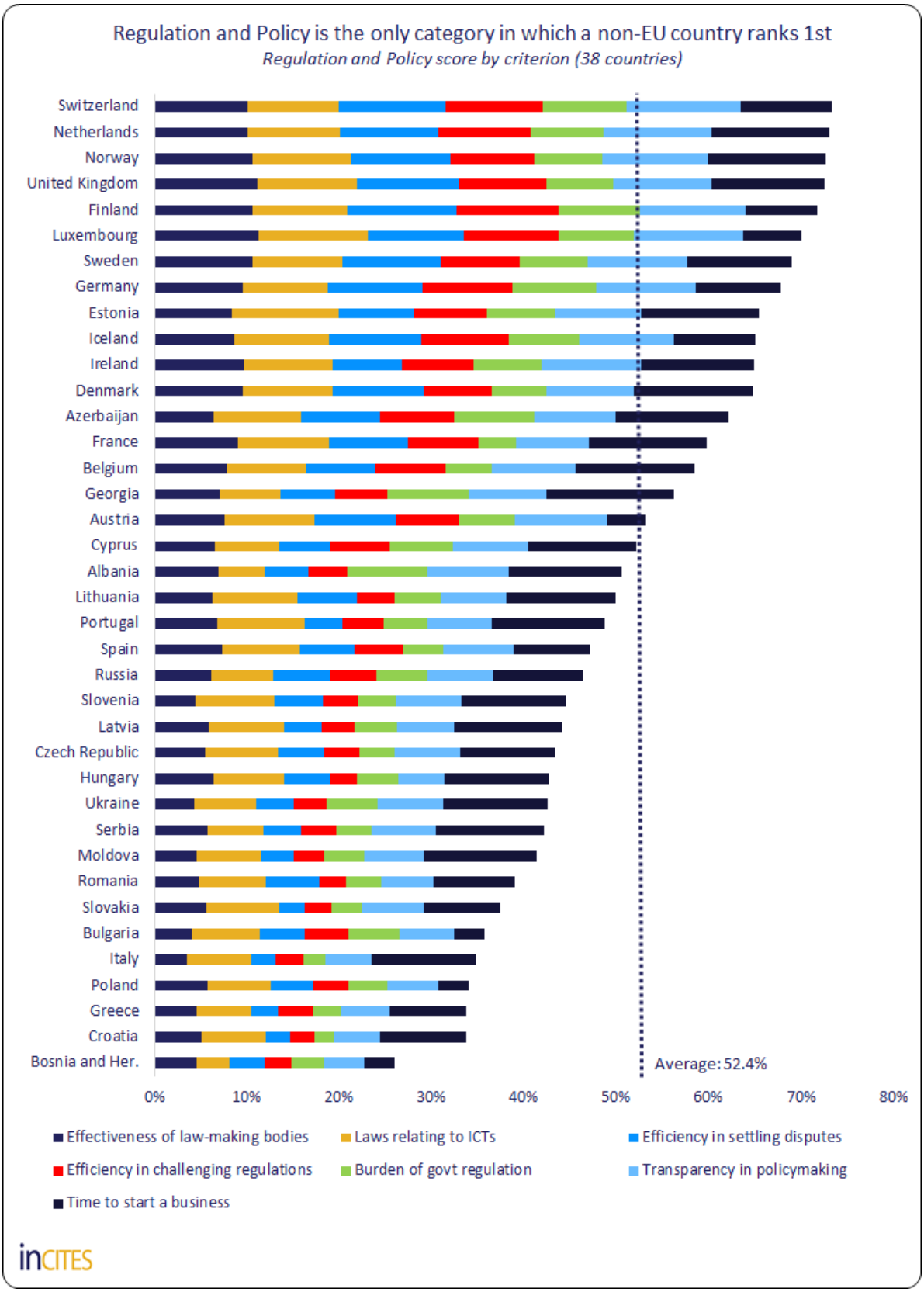
3.2 Regulation and Policy

This category includes factors that relate to the regulatory and policy frameworks that will be key to facilitate the smooth and swift deployment of 5G networks. 5G is going to use two new frequency bands, namely 3.6 GHz and 26 GHz, which will be essential to achieve the higher data rates it promises. This will only be possible by deploying a larger number of small cells, due to the shorter transmission range that higher frequencies can achieve. With 5G it is expected that the deployment of a large number of macro and small cell antennas will be required to accommodate the increasing demand for capacity. Past regulatory practice was generally based on the requirements of physically larger high-power macrocells, which might not be appropriate in the case of networks with smaller cells. Enabling the deployment of small cell networks requires streamlined federal, state and local permitting, rights-of-way, application submission timelines, application fees, application review timelines and appeals processes to make it economically feasible for operators to deploy 5G across communities.

The greatest variability in the scores between the different criteria is observed in the *no. of days to start a business* criterion. The intuition behind the use of this criterion was to capture a metric that would represent the ease of setting up a business in each country. 5G will enable new and disruptive business models that will overhaul the entire telecoms value chain. As a result it is important for new start-ups that develop new 5G services and applications to be able to easily set up shop. This will foster innovation and help create an ecosystem around 5G. The creation of an ecosystem is important as 5G will transform the telecoms value chain and re-define the existing bilateral relationships, with new players entering the market and existing players seeing their roles change. Hence, it is likely that in countries where it takes long to set up a business, 5G development and adoption will be hindered, at least in the early stage. However, correlation analysis between the *no. of days to start a business* criterion and each of the criteria in the *Innovation Environment* category shows little correlation between the two.

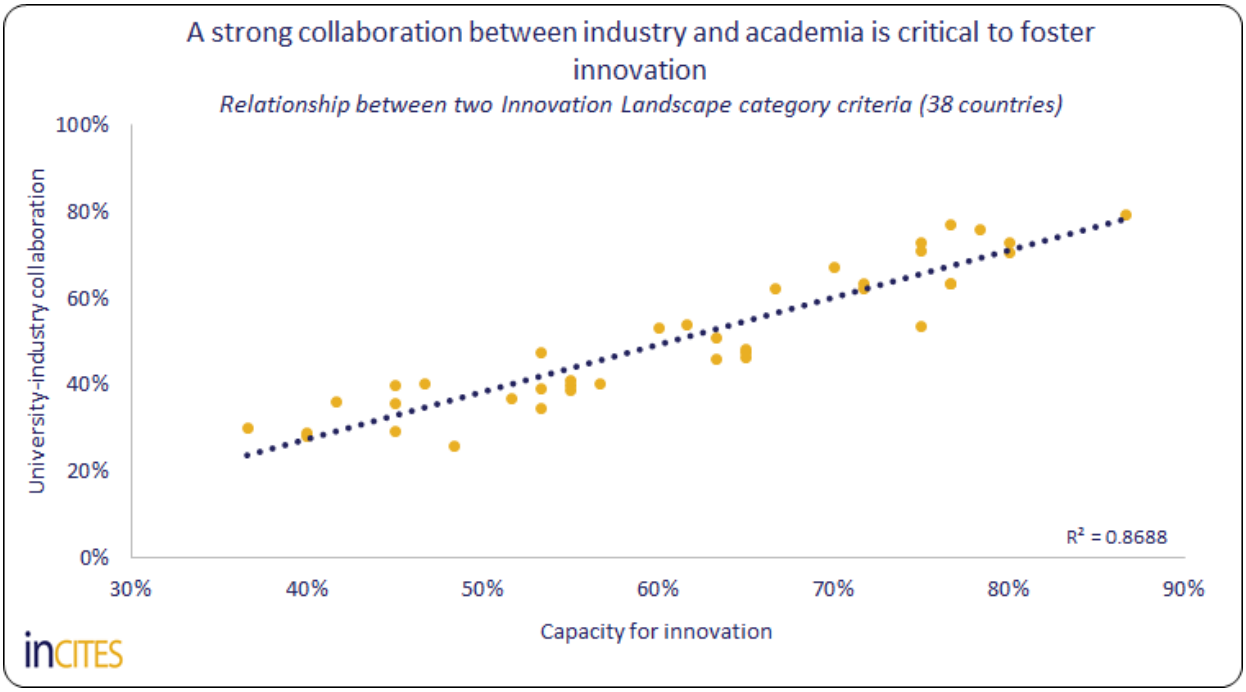
Interesting Data Points

- Western European countries score an average of 60.9 in this category, while the Eastern European average stands at 42.9 and the overall average at 52.4. The highest ranked E. European country in the category is Azerbaijan at the 13th position.
- Italy and Greece have the two lowest positions in this category amongst all Western European markets, due to their low scores in the *effectiveness of law-making bodies* and *burden of govt regulation* criteria.
- Albania has the highest score (50.6) of all Balkan countries in this category, as well as several W. European countries, such as Spain, Portugal, Italy and Greece. However, this is the only category in which Albania ranks above the 30th position (19th).
- Luxembourg ranks between 1st and 7th in 6 out of the 7 criteria, though it ranks in the 34th position in the *no. of days to start a business* criterion, which brings it overall in the 6th position in this category. Luxembourg ranks 1st in both the *effectiveness of law-making bodies* and *laws relating to ICTs* criteria, which further highlight its capability to make the necessary regulatory interventions needed for 5G to flourish in the country.
- *Regulation and policy* is the only category in which a non-EU country (Switzerland) ranks 1st.


Regulation and Policy is the only category in which a non-EU country ranks 1st
Regulation and Policy score by criterion (38 countries)
Switzerland
Netherlands
Norway
United Kingdom
Finland
Luxembourg
Sweden
Germany
Estonia
Iceland
Ireland
Denmark
Azerbaijan
France
Belgium
Georgia
Austria
Cyprus
Albania
Lithuania
Portugal
Spain
Russia
Slovenia
Latvia
Czech Republic
Hungary
Ukraine
Serbia
Moldova
Romania
Slovakia
Bulgaria
Italy
Poland
Greece
Croatia
Bosnia and Her.
Average: 52.4%
0%
10%
20%
30%
40%
50%
60%
70%
80%
Effectiveness of law-making bodies
Laws relating to ICTs
Efficiency in settling disputes
Efficiency in challenging regulations
Burden of govt regulation
Transparency in policymaking
Time to start a business
inCITES

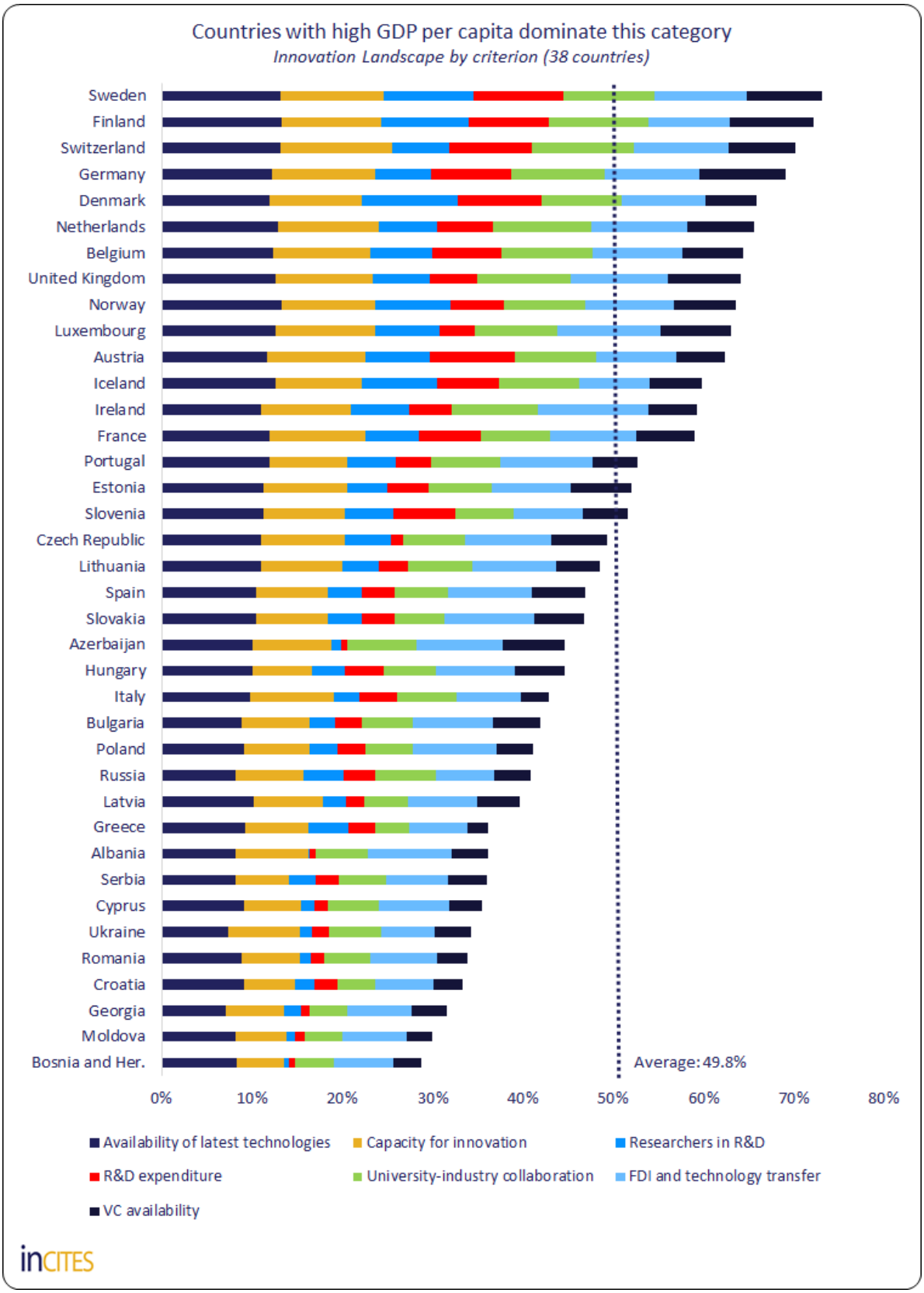
3.3 Innovation Landscape

This category includes factors that relate to potential contributors to the development of the new technology from a research and financial perspective. 5G is all about innovation. Innovation in the provided services and business models as well as the way the network is set up to provide seamless connectivity to tens or hundreds of thousands of devices. Hence, a skilled research community coupled with strong financial backing for R&D could create sustainable competitive advantages for an economy. The figure below highlights the importance of a strong relationship between academia and the market in fostering innovation.



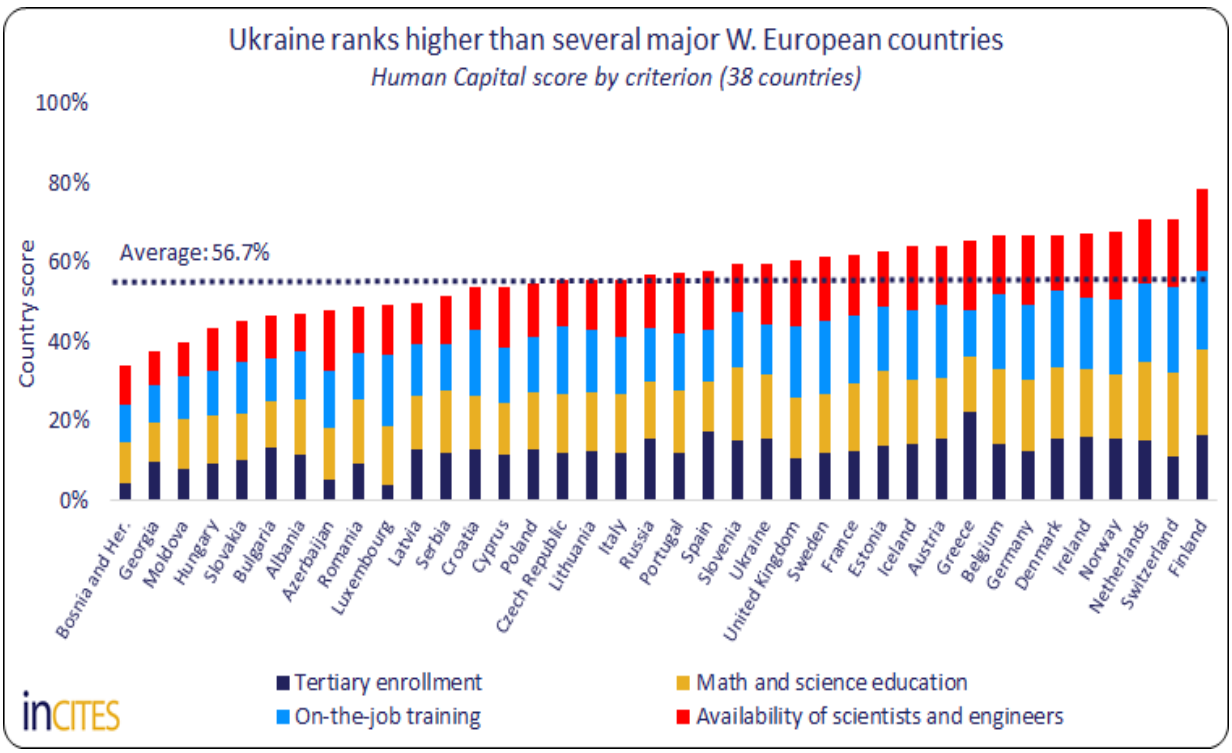
Interesting Data Points

- This category is dominated by W. European countries. The first E. European country, Slovenia, ranks only in the 17th position. The average W. Europe country score is 58.9, while the same figure stands at 39.6 for E. European countries. The average of all countries is 49.8.
- There is a 0.77 correlation between *GDP per capita* and the *aggregate Innovation Landscape* score, likely because wealthier countries are in a better position to fund R&D activities.
- Although Denmark ranks 1st and 3rd in the *researchers in R&D* and *R&D expenditure* criteria, respectively, due to its top-tier universities and research community, it fails to rank above the 11th position in any of the remaining criteria. Overall, Denmark ranks 5th in this category.
- Italy (24th), Greece (29th) and Cyprus (32nd) are the lowest-ranked W. European countries, all ranking very low in the *venture capital availability* criterion. This is likely due to the turbulent economic and political situation that these countries have faced in the recent years which shifted the Venture Capitalists' focus away from them.


Countries with high GDP per capita dominate this category
Innovation Landscape by criterion (38 countries)
Sweden
Finland
Switzerland
Germany
Denmark
Netherlands
Belgium
United Kingdom
Norway
Luxembourg
Austria
Iceland
Ireland
France
Portugal
Estonia
Slovenia
Czech Republic
Lithuania
Spain
Slovakia
Azerbaijan
Hungary
Italy
Bulgaria
Poland
Russia
Latvia
Greece
Albania
Serbia
Cyprus
Ukraine
Romania
Croatia
Georgia
Moldova
Bosnia and Her.
Average: 49.8%
0%
10%
20%
30%
40%
50%
60%
70%
80%
Availability of latest technologies
Capacity for innovation
Researchers in R&D
R&D expenditure
University-industry collaboration
FDI and technology transfer
VC availability
inCITES

3.4 Human Capital

This category includes factors that relate to quality of the education system and training initiatives that could be useful in deploying and adopting new technologies. 5G is a new technology which finely orchestrates existing technologies to achieve the advanced properties it promises. As such, qualified personnel and solid engineering expertise will help in the swift development of 5G networks, the creation of new more exciting applications and use cases that take advantage of the characteristics of 5G. Consequently, a tech-savvy Human Capital supported by training initiatives could also help in stimulating the adoption of the new technology. The greatest variability among the countries exists in the *tertiary enrollment* criterion and, despite popular belief, there is very little correlation between *tertiary enrollment* and *GDP per capita* (R^2=0.08). This is likely because wealthier countries are capable of attracting foreign talented Human Capital to their countries, a phenomenon that is particularly acute in the EU, due to the free movement of labour.



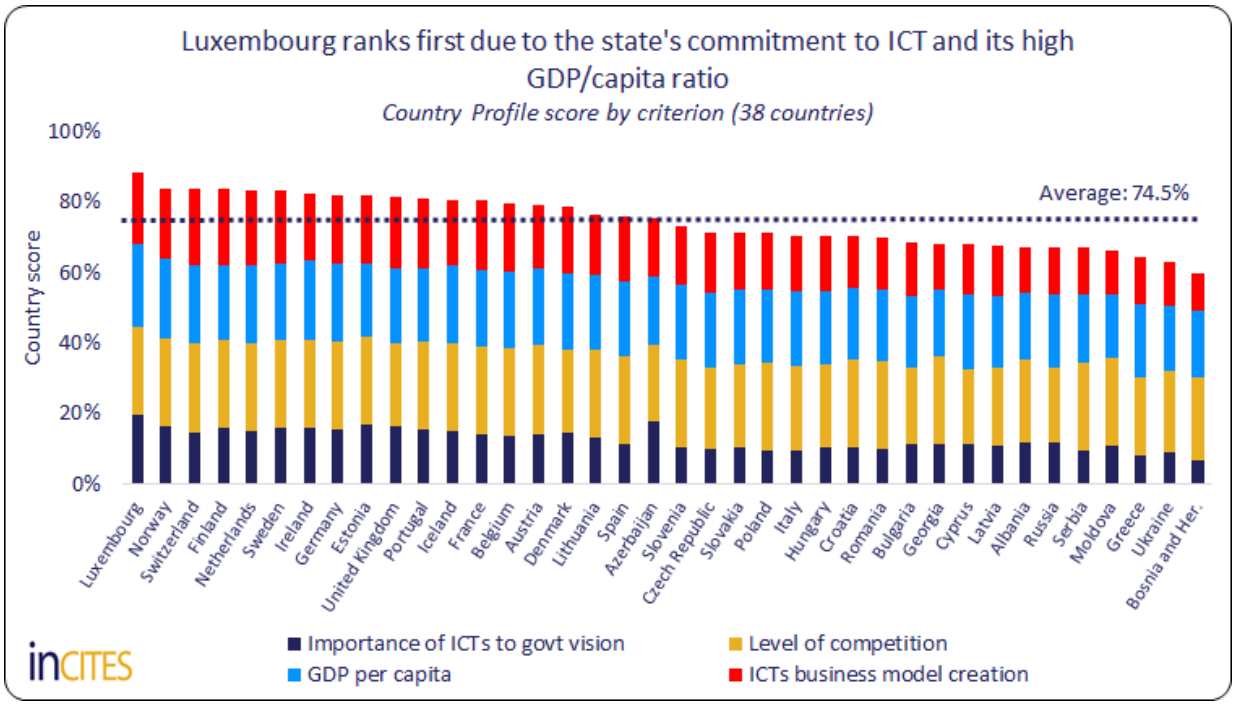
Interesting Data Points

- The average score for W. European countries is 63.3 and 49.2 for E. European. The average score of all countries in 56.7.
- Greece ranks 9th in this category, its highest rank in all categories, due to its high scores in the *tertiary enrollment* (1st) and *availability of scientists and engineers* (2nd) criteria.
- Luxembourg ranks 32nd in this category, its lowest rank across all categories, due to its low rank in the *tertiary enrollment* criterion (38th).
- Finland has one of the most efficient educational systems in the world, hence its rank in this category (1st). Finnish universities are also famous for their R&D activities, something that will prove very useful in the 5G era.
- Ukraine has the highest score of all E. European countries (59.6, 16th place), also higher than several major W. European countries, such as the UK, Spain, Portugal and Italy.

3.5 Country Profile

This category includes factors that relate to the existing economic state of a country, ICT industry competition and the government's support of new technologies. Deploying 5G does not come cheap. Hence, in many cases, state support will be required for the development of 5G pilots in some countries. State support might be financial, procedural, regulatory or legislative. Countries with higher *GDP per capita* are also more likely to deploy and adopt 5G faster due to the increasing purchasing power of their citizens. What is also key, is the importance of ICTs to the state's planning and vision. The more important ICTs are to a state, the higher the chances it will invest in new technologies.

The lowest variability between the countries across the criteria exists for the *level of competition* criterion, where most of the countries get the top score. This implies that market competition is high enough to drive existing operators to invest in new technologies so to gain competitive advantage over their peers. The greatest variability exists in the *importance of ICTs to government vision* criterion which varies greatly between Western and Eastern European countries, likely due to the cohesive framework that the EU has as compared to E. European countries.



Interesting Data Points

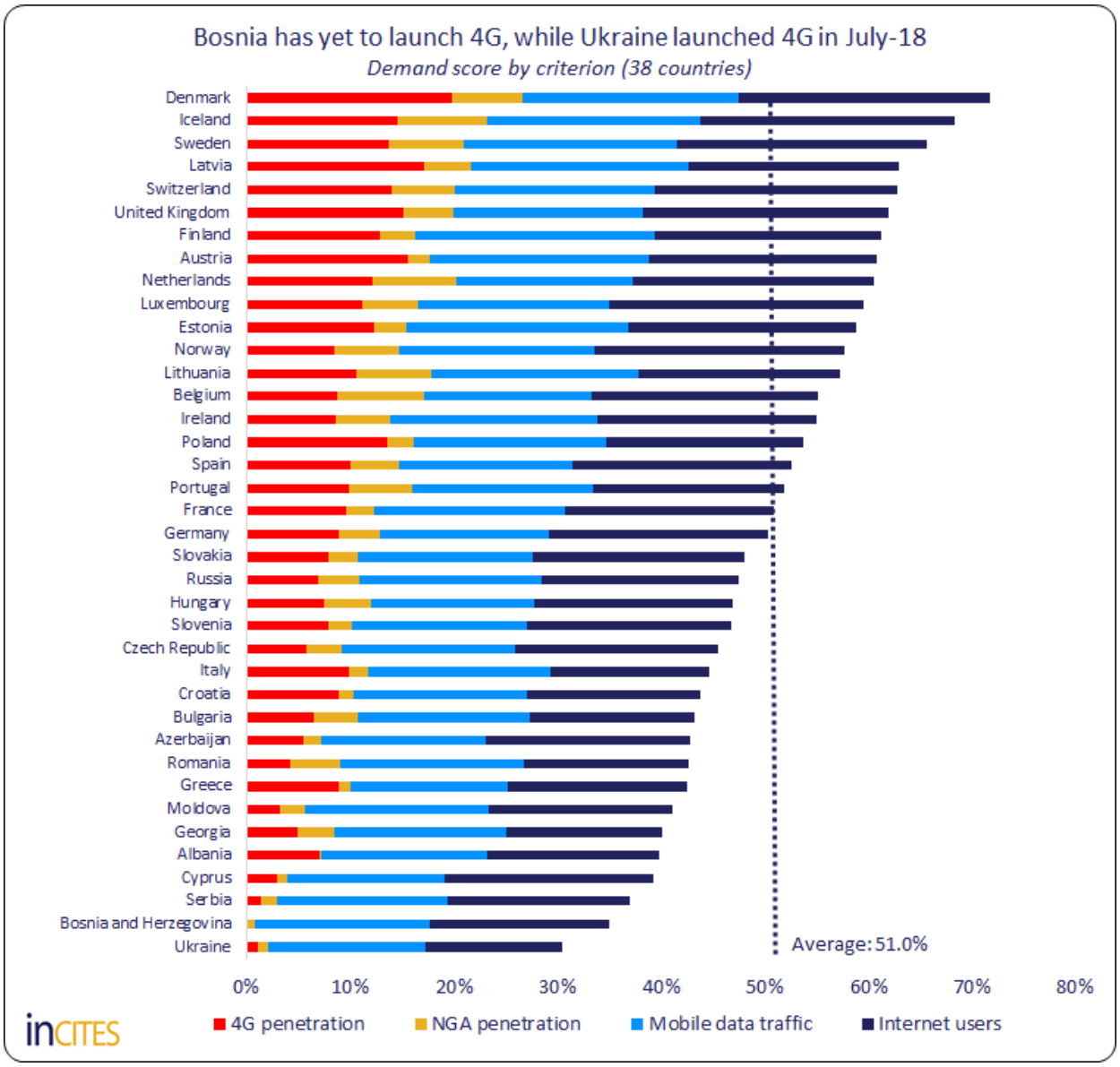
- The *Country Profile* category has the lowest score difference between Western and Eastern European countries of all categories. The average W. European country score is 79.5, 69.0 for E. European countries and 74.5 overall.
- Luxembourg ranks first in this category (its highest score among all categories), due to both its high *GDP per capita* and the state's commitment in promoting ICTs, in both of which criteria Luxembourg ranks first.
- Azerbaijan ranks 2nd in the *Importance of ICTs to govt vision* but scores quite low on the rest of the criteria. In fact, ICT is Azerbaijan's second most profitable sector after hydrocarbons and the second largest recipient of *Foreign Direct Investment (FDI)* after the oil and gas industry. The state is fully committed behind the sector's growth, indicating the importance of ICT to the country's future.

3.6 Demand

This category includes factors that relate to the adoption of new fixed and mobile technologies as well as the use of the Internet. Technology development and adoption is like the 'chicken or the egg dilemma' in the telecoms world. In other words, some believe in the 'if you build it, they will come' theory, whereby operators offer the latest and greatest technologies to their clients with the hope that they will adopt them, whereas others think that customer demand is what drives investment by the operators and not the other way around. In any case, technology adoption is critical for the sustainability of the operators' business model.

The greatest variability between the countries across the criteria exists in the *4G penetration* criterion. This is due to the fact that Bosnia and Herzegovina has not yet launched 4G, while Ukraine launched 4G in July 2018, 8.5 years after the first 4G network went live. As a result, Bosnia and Herzegovina and Ukraine rank in the last two positions of the table.

Customer demand for connectivity services continues to grow as digital literacy improves across the board.



Interesting Data Points

- The average score for W. European countries is 56.6, 44.7 for E. European countries and 51.0 for all countries.
- Latvia ranks 4th in this category, its highest rank across all categories, due to its high scores in the *4G penetration* (2nd) and *mobile data traffic* (4th) criteria. Latvia is the only E. European country that achieves this high a rank across any category.
- Italy (26th), Greece (31st) and Cyprus (35th) are the lowest-ranked W. European markets. This is mainly due to the low *coverage of NGA networks* and low *4G take-up* as compared to their European counterparts. However, plans for NGA network deployment have been outlined by operators in all three countries, which will contribute to closing the current Digital Divide between South and North EU countries.

3.7 Correlation Analysis

To identify the relationship between the various factor categories a correlation analysis was conducted. The results show that there is positive and statistically significant correlation between the different factors, ranging from 52% between *Regulation and Policy* and *Infrastructure and Technology* to 91% between *Innovation Landscape* and *Country Profile*. These results could be explained as follows:

1. There is an overlap between the underlying variables that constitute each of the factors with the variables that constitute other factors.
2. All factors tend to move in the same direction. Hence, if a country improves in one of the factors in the future, the rest of the factors will also likely improve.
3. The high correlation between the *Country Profile* and *Innovation Landscape* factors implies that the better the economic status and the state's vision to support new technologies, the more financial support is provided to R&D purposes. The relationship between *Country Profile* and *Regulation and Policy* could also be interpreted in the same way.
4. The 'low' correlation between *Infrastructure and Technology* and *Regulation and Policy* is likely due to the fact that the *Regulation and Policy* category does not only include ICT-specific criteria. If one calculates the correlation between the *laws relating to ICTs* criterion and I*nfrastructure and Technology* the correlation increases to 68%. Although the *Regulation and Policy* category does not include only ICT-specific criteria, it was included in the construction of the Index due to several legal considerations that 5G will complicate, such as site planning, licensing and rights of way.

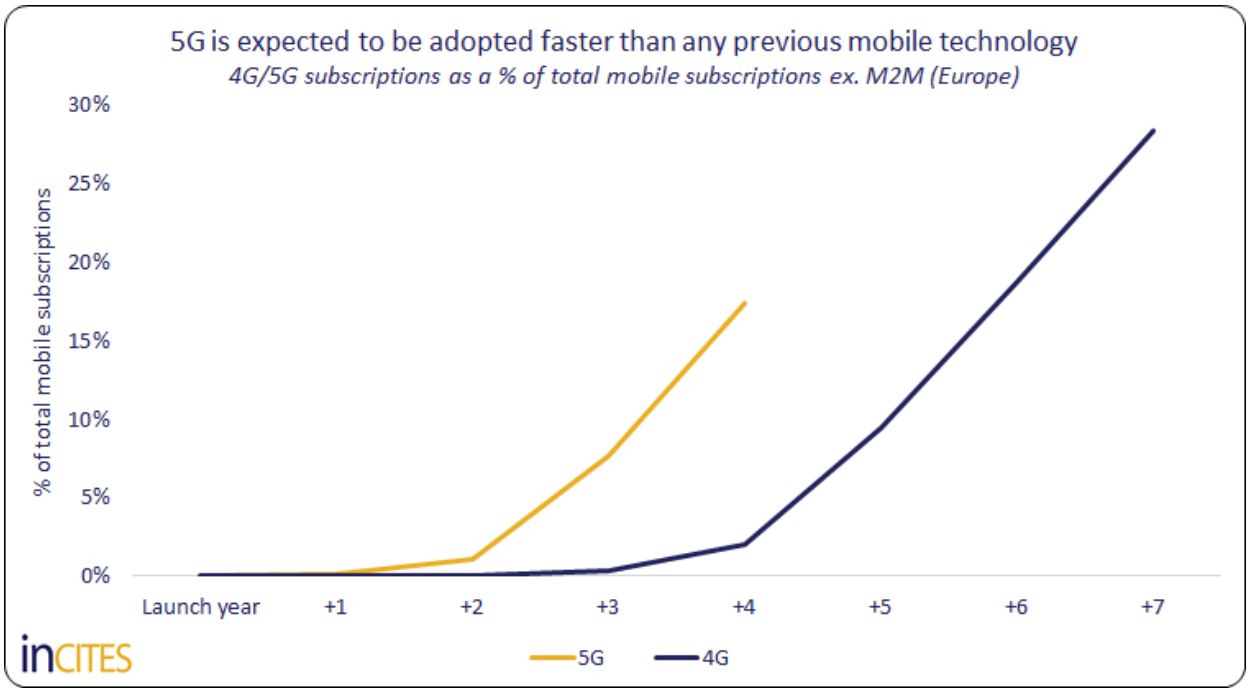
Table 4 Correlation between main factors

Correlation matrix	Infrastructure & Technology	Regulation and Policy	Innovation Landscape	Human Capital	Country Profile	Demand
Infrastructure & Technology	100%	52%	70%	57%	71%	71%
Regulation and Policy		100%	82%	62%	86%	68%
Innovation Landscape			100%	76%	91%	81%
Human Capital				100%	66%	60%
Country Profile					100%	79%
Demand						100%

04 inCITES Europe 5G Subscription Forecast

As part of our Mobile and Fixed Connectivity database, Prognosis, we generate granular market sizing forecasts for 41 European countries, across over 160 KPIs, totalling over 110k unique data points. inCITES Consulting's mobile and fixed connectivity historical data are based on a number of inputs from trusted sources, including regulator reports, network operator reports, news articles, statistics agencies, international bodies and other insights from conversations with our clients and partners. We place data integrity and robustness on top of our agenda and we have implemented a robust research and analysis process of all available datasets of operational, demographic and socioeconomic data.

inCITES forecasts that 5G will reach 181 million subscriptions by 2023, accounting for 17.4% of total mobile subscriptions excluding M2M, up from a few thousand connections in 2019. W. Europe will account for the vast majority of 5G subscriptions throughout the forecast period, ahead of E. Europe.



Key takeaways:

- **5G will be adopted faster than its predecessors.** Widen installed customer base, higher tech savviness, fiercer operator competition and faster smartphone price erosion will drive this.
- **5G take-up will accelerate after 2022**. Coverage expansion, network upgrade from NSA to SA, device price erosion, technology maturity, availability of 5G-enabled devices and introduction of advanced services and applications will drive this.
- **W. Europe will have over 150m 5G subscriptions by 2023.** This figure is over 9x higher than the 4G subscriptions after the launch of 4G on a like-for-like basis. A handful of countries will launch in 2019, though the bulk of them will go live in 2020, in-line with EU's digital agenda targets.
- **E. Europe will have over 30m 5G subscriptions by 2023.** This figure is over 7x higher than the 4G subscriptions after the launch of 4G on a like-for-like basis. Several countries will launch 5G in 2020, though its take-up will lag behind that of W. Europe.

05 Scenario Analysis

In order for the factors that constitute the Europe 5G Readiness Index to have a fair representation in the overall Index score, the data analysis performed in the former sections comes from an equally-weighted Index. Both the weights of the criteria within each category as well as the weights of the categories themselves were set to be equal. This implies that all categories and criteria within them are of equal importance to a country's readiness for 5G.

An alternative scenario was examined by altering the weights of both the factor categories and criteria (more info can be found in the Europe 5G Readiness Index Methodology document) within them based on discussions with clients and partners as well as inCITES experts' opinions and expectations. The results of this analysis show that there was little variation between the initial and new overall rankings as shown in the Table below.

Interesting Data Points

- Austria saw the highest ranking improvement (+2 positions) while both Ireland and Cyprus saw the highest ranking deterioration (-2 positions).
- The average position change across all criteria was by 0.7 positions as compared to the equally-weighted ranking.

Table 5 5G Readiness Index – Unequal weights

Total Rank (+/-)	Country Name	Total Score	Infrastructure and Technology		Regulation and Policy		Innovation Landscape		Human Capital		Country Profile		Demand	
			Score	Rank (+/-)	Score	Rank (+/-)	Score	Rank (+/-)	Score	Rank (+/-)	Score	Rank (+/-)	Score	Rank (+/-)
1 (0)	Finland	72.3	64.9	3 (+2)	72.3	5 (0)	72.6	2 (0)	79.4	1 (0)	85.4	4 (0)	59.5	8 (-1)
2 (0)	Sweden	70.0	66.6	1 (0)	68.9	7 (0)	73.8	1 (0)	61.9	14 (0)	85.1	6 (0)	63.6	3 (0)
3 (0)	Switzerland	69.6	55.1	13 (-2)	72.8	2 (-1)	70.6	3 (0)	72.1	2 (+1)	85.7	3 (0)	60.9	5 (0)
4 (+1)	Denmark	68.0	57.9	10 (0)	64.6	12 (0)	67.2	5 (0)	66.5	8 (-1)	80.9	16 (0)	70.8	1 (0)
5 (-1)	Netherlands	67.8	54.9	14 (0)	72.2	6 (-4)	64.8	6 (0)	71.1	3 (-1)	85.3	5 (0)	58.3	9 (0)
6 (0)	Norway	67.6	61.2	8 (0)	72.6	3 (0)	63.0	9 (0)	68.1	4 (0)	86.0	2 (0)	54.6	13 (-1)
7 (+1)	United Kingdom	66.5	58.5	9 (0)	72.9	1 (+3)	62.6	10 (-2)	61.3	15 (+2)	83.2	10 (0)	60.2	6 (0)
8 (-1)	Germany	66.3	62.2	6 (-4)	67.5	8 (0)	68.7	4 (0)	67.6	5 (+4)	84.1	8 (0)	47.9	20 (0)
9 (0)	Iceland	65.2	51.1	16 (0)	65.6	10 (0)	60.4	12 (0)	64.3	10 (+1)	83.2	11 (+1)	66.4	2 (0)
10 (0)	Luxembourg	64.5	56.1	12 (0)	72.4	4 (+2)	60.9	11 (-1)	50.8	28 (+4)	89.9	1 (0)	56.8	11 (-1)
11 (0)	France	62.5	62.6	5 (-1)	60.1	14 (0)	58.8	13 (+1)	62.1	13 (0)	82.7	13 (0)	48.8	19 (0)
12 (+2)	Austria	62.1	48.5	21 (-1)	55.3	16 (+1)	63.9	8 (+3)	63.7	11 (-1)	81.8	15 (0)	59.5	7 (+1)
13 (-1)	Ireland	62.0	45.3	22 (+1)	64.8	11 (0)	57.8	14 (-1)	66.9	6 (0)	84.9	7 (0)	52.5	16 (-1)
14 (-1)	Estonia	61.7	50.2	18 (+1)	66.1	9 (0)	50.8	17 (-1)	62.5	12 (0)	83.7	9 (0)	56.9	10 (+1)
15 (0)	Belgium	61.3	44.5	24 (+4)	57.6	15 (0)	64.4	7 (0)	66.6	7 (+1)	82.0	14 (0)	52.5	15 (-1)
16 (0)	Portugal	58.9	61.6	7 (0)	49.6	20 (+1)	51.3	16 (-1)	58.1	18 (+2)	82.9	12 (-1)	50.1	18 (0)
17 (0)	Spain	57.8	66.6	2 (+1)	48.3	21 (+1)	45.3	20 (0)	57.0	19 (-1)	79.2	18 (0)	50.4	17 (0)
18 (0)	Lithuania	56.5	50.9	17 (+1)	50.3	19 (+1)	47.1	18 (+1)	55.7	22 (-1)	79.3	17 (0)	55.6	12 (+1)
19 (0)	Slovenia	53.7	45.2	23 (-1)	44.5	24 (0)	52.2	15 (+2)	59.0	17 (-1)	76.8	20 (0)	44.5	24 (0)
20 (0)	Latvia	53.5	56.1	11 (+2)	44.4	25 (0)	38.0	28 (0)	48.9	31 (-3)	71.0	32 (-1)	62.4	4 (0)
21 (0)	Czech Republic	52.7	53.0	15 (+2)	43.6	26 (0)	46.8	19 (-1)	55.5	23 (0)	74.8	22 (-1)	42.8	26 (-1)
22 (+1)	Italy	52.6	64.3	4 (+2)	34.6	35 (-1)	42.9	23 (+1)	56.2	21 (+1)	74.2	25 (-1)	43.6	25 (+1)
23 (-1)	Russia	51.2	48.7	20 (-5)	45.7	23 (0)	40.5	25 (+2)	56.6	20 (-1)	70.4	34 (-1)	45.0	22 (0)
24 (0)	Azerbaijan	50.6	34.2	35 (0)	61.1	13 (0)	41.4	24 (-2)	50.0	29 (+4)	76.9	19 (0)	39.9	31 (-2)
25 (0)	Poland	50.0	41.8	28 (-4)	36.0	34 (+1)	39.6	27 (-1)	54.8	24 (0)	75.1	21 (+2)	52.7	14 (+2)
26 (0)	Slovakia	48.9	44.1	25 (+1)	38.8	32 (0)	44.9	21 (0)	45.1	34 (0)	74.7	23 (-1)	45.5	21 (0)
27 (0)	Hungary	48.7	44.1	26 (+4)	43.0	27 (0)	43.3	22 (+1)	43.6	35 (0)	73.8	27 (-2)	44.6	23 (0)
30 (-1)	Greece	47.4	40.7	30 (-1)	33.9	37 (-1)	35.9	29 (0)	64.5	9 (-4)	68.6	36 (0)	40.8	29 (+2)
28 (0)	Cyprus	47.7	40.2	31 (0)	50.8	18 (0)	33.7	31 (+1)	54.3	25 (+1)	71.3	31 (-1)	35.9	35 (0)
29 (+1)	Romania	47.6	50.1	19 (+2)	39.4	31 (0)	32.3	35 (-1)	49.4	30 (-1)	73.9	26 (+1)	40.3	30 (0)
31 (0)	Croatia	46.3	40.9	29 (-2)	34.5	36 (+1)	32.6	34 (+1)	53.1	26 (-1)	74.2	24 (+2)	42.2	27 (0)
32 (0)	Bulgaria	45.5	37.3	33 (0)	37.3	33 (0)	40.1	26 (-1)	45.9	33 (-3)	71.3	30 (-2)	41.3	28 (0)
33 (0)	Serbia	45.1	37.8	32 (0)	41.2	29 (0)	34.8	30 (+1)	51.5	27 (0)	71.3	29 (+5)	33.7	36 (0)
34 (0)	Albania	44.2	28.9	36 (0)	48.1	22 (-3)	33.5	32 (-2)	46.5	32 (-1)	70.6	33 (-1)	37.9	34 (0)
35 (0)	Georgia	44.2	34.8	34 (0)	53.8	17 (-1)	29.6	36 (0)	37.2	37 (0)	71.8	28 (+1)	38.1	33 (0)
36 (0)	Moldova	43.4	43.5	27 (-2)	40.6	30 (0)	28.3	37 (0)	40.0	36 (0)	69.9	35 (0)	38.2	32 (0)
37 (0)	Ukraine	42.4	25.3	38 (0)	41.5	28 (0)	33.1	33 (0)	59.6	16 (-1)	66.8	37 (0)	28.0	38 (0)
38 (0)	Bosnia and Herzegovina	35.1	25.4	37 (0)	26.3	38 (0)	27.0	38 (0)	35.3	38 (0)	64.8	38 (0)	31.6	37 (0)

06 About inCITES Consulting

inCITES Consulting is an innovative research, data and advisory firm specialising in the ICT market. Our mission is to support business and technology leaders make informed decisions on technology purchases and business strategy. Our executives have extensive experience in network engineering and the economics of the ICT sector with more than 100 scientific publications and over 300 citations in the past 20 years.

The list of our satisfied customers includes some of the largest telecoms operators, vendors, integrators, governments, universities and telecom regulators globally. We also act as a trusted research and innovation partner for the European Commission on cutting edge research projects mainly in the areas of 5G, Cyber Security and Data Centres.

Our wide range of capabilities include:

- Business Modelling
- Technoeconomic Analysis
- Business Planning
- Value Chain Analysis
- Regulatory Economics
- Demand Forecasting and Market Sizing
- Market Analysis
- Socioeconomic Impact Analysis
- Cost Benefit Analysis
- Technology roadmapping

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