EUROPEAN COMMISSION
Directorate-General for Communications Networks, Content and Technology

Digital Economy and Coordination
European Semester and Knowledge Base

DESI 2015

Digital Economy and Society Index

Methodological note

Commission européenne/Europese Commissie, 1049 Bruxelles/Brussel, BELGIQUE/BELGIË - Tel. +32 22991111
Office: BU25 01/199 - Tel. direct line +32 229-91216
alexandre.mateus@ec.europa.eu

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1 Introduction

The Digital Economy and Society Index (DESI) measures progress of EU countries towards a digital economy and society. As such, it brings together a set of relevant indicators on Europe's current digital policy mix.

The index allows four main types of analysis:

- General performance assessment: to obtain a general characterisation of the performance of individual Member States by observing their overall index score and the scores of the main index dimensions.
- Zooming-in: to pinpoint the areas where Member State performance could be improved by analysing the scores of the index's sub-dimensions and individual indicators.
- Follow-up: to assess whether there is progress over time.
- Comparative analysis: to cluster Member States according to their index scores, comparing countries in similar stages of digital development so as to flag the need for improvement in relevant policy areas.

The DESI was developed following the guidelines and recommendations in the OECD's "Handbook on constructing composite indicators: methodology and user guide"[1]. The data included in the index were mostly collected by the European Commission services (DG CNECT, Eurostat), with the exception of two indicators collected by IHS[2] as part of their TV Media Intelligence service and by ad-hoc studies launched by the Commission services.

This document presents the methodological steps taken in the development of the DESI. It starts by focusing on the structure of the index (section 2), followed by considerations on the options taken during the development (section 3) and on the presentation of the main results and robustness analysis (section 4).

[1] http://www.oecd.org/els/soc/handbookonconstructingcompositeindicatorsmethodologyanduserguide.htm

[2] https://technology.ihs.com

2 Structure of the DESI

The DESI has a three-layer structure as depicted in table 1. It is composed of 5 principal dimensions, each divided in a set of sub-dimensions, which are in turn composed by individual indicators.

1 Connectivity	1a Fixed Broadband	1a1 Fixed BB Coverage
		1a2 Fixed BB Take-up
	1b Mobile Broadband	1b1 Mobile BB Take-up
		1b2 Spectrum
	1c Speed	1c1 NGA Coverage
		1c2 Subscriptions to Fast BB
	1d Affordability	1d1 Fixed BB Price
2 Human Capital	2a Basic Skills and Usage	2a1 Internet Users
		2a2 Basic Digital Skills
	2b Advanced skills and Development	2b1 ICT Specialists
		2b2 STEM Graduates
3 Use of Internet	3a Content	3a1 News
		3a2 Music, Videos and Games
		3a3 Video on Demand
		3a4 IPTV
	3b Communication	3b1 Video Calls
		3b2 Social Networks
	3c Transactions	3c1 Banking
		3c2 Shopping
4 Integration of Digital Technology	4a Business digitization	4a1 Electronic Information Sharing
		4a2 RFID
		4a3 Social Media
		4a4 eInvoices
		4a5 Cloud
	4b eCommerce	4b1 SMEs Selling Online
		4b2 eCommerce Turnover
		4b3 Selling Online Cross-border
5 Digital Public Services	5a eGovernment	5a1 eGovernment Users
		5a2 Pre-filled Forms
		5a3 Online Service Completion
		5a4 Open Data
	5b eHealth	5b1 Medical Data Exchange
		5b2 ePrescription

Table 1. DESI Structure

At high level the DESI addresses the five principal policy areas of concern for a digital economy and society. These are not isolated areas that contribute separately to digital development but are in fact interconnected. As such, developments in the digital economy cannot be achieved through isolated improvements in particular areas but through concerted improvement in all areas.

2.1 Connectivity dimension

A necessary condition for the development of a digital society is the ability of its members to connect to the Internet. Nowadays however, a simple Internet connection is no longer sufficient. In order to benefit from the full spectrum of developments brought about by the Internet, a high-speed Internet connections starts to be desirable, if not mandatory. Hence connectivity is a necessary infrastructure of the digital economy and society.

The Connectivity dimension is divided into four sub-dimensions, each focusing on a relevant aspect of connectivity to the Internet.

2.1.1 Fixed Broadband

This sub-dimension focuses on whether citizens have the possibility to connect to the Internet via a fixed broadband connection, and on the extent to which they do in fact connect to the Internet that way. These phenomena are captured respectively by the Fixed BB Coverage and by the Fixed BB Take-up indicators.

2.1.2 Mobile Broadband

This sub-dimension focuses on whether citizens use the broadband capabilities of their mobile devices (Mobile BB Take-up indicator) and on whether each member state is taking the necessary steps to release and put to use the necessary radio-frequency spectrum to enable wireless broadband Internet service (Spectrum indicator).

2.1.3 Speed

The Speed sub-dimension focuses on the availability and use of high-speed Internet connections (defined as those offering at least 30 Mbps download speed). The availability of such connections is captured in the NGA Coverage indicator, whereas the actual use of such connections by the population is captured in the Subscriptions to Fast broadband (BB) indicator.

2.1.4 Affordability

Finally, this sub-dimension measures how affordable it is to have a broadband Internet connection by means of the Fixed broadband (BB) price indicator, which captures the minimum price that a potential user would have to pay to obtain a basic fixed broadband connection (allowing at least 12 Mbps) as a percentage of her gross income.

2.2 Human Capital Dimension

Having a connection to the Internet is not sufficient; it must be paired with the appropriate skills to take advantage of the Internet and of the myriad of possibilities unravelled by a digital society. Those skills go from basic usage skills that enable individuals to take part

in the digital society and consume digital goods and services, to advanced skills that empower the workforce to develop new digital goods and services and to take advantage of technology for enhanced productivity and economic growth. Digital skills are also a necessary infrastructure for the digital economy and society.

The Human Capital dimension is divided into two sub-dimensions.

2.2.1 Basic Skills and Usage

The Basic Skills and Usage sub-dimension captures the digital skills level of the general population. In particular, it assesses whether citizens are able to use the Internet and use it on a regular basis (Internet Users indicator) and whether they possess at least a basic level of digital skills (captured by the Basic Digital Skills, which measures whether citizens have at least basic skills in at least one of four Digital Competence domains: information, communication, content-creation or problem-solving).

2.2.2 Advanced skills and Development

The Advanced skills and Development sub-dimension concerns the workforce and its potential to maintain and grow the digital economy. It takes into account the percentage of people in the workforce with ICT specialist skills (ICT Specialists indicators) and the share of the population with STEM (science, technology, engineering and mathematics) education (STEM graduates indicator).

2.3 Use of Internet Dimension

Citizens that are empowered with an Internet connection and the necessary skills to take advantage of it can engage in a wide range of online activities. These can be through consumption of online content (e.g., entertainment such as music, movies, TV or games, obtaining media-rich information or engaging in online social interaction), through modern communication activities (e.g., performing video-calls), or through eCommerce. Nowadays this mix of activities can only be enjoyed to its fullest using the high-speed connectivity provided by a broadband subscription. Hence, these content-rich activities are among the drivers of the development of broadband networks. On the demand side, it is the possibility to perform these activities that drives users to subscribe to broadband connections. On the supply side, it is the need for the network capacity and speed to support such services that drives the supply of faster networks and better content delivery facilities.

The Use of Internet dimension is divided into three sub-dimensions.

2.3.1 Content

The Content sub-dimension measures the extent to which a country's Internet users get online content via their broadband connections. It uses four indicators to portray the country's consumption of content online: the percentage of Internet users that read news online (News indicator); the percentage of Internet users that consume music, videos or games online (Music, Videos and Games indicator); and the percentages of households that subscribe to Video on Demand (Video on Demand indicator) or to IPTV (IPTV indicator).

2.3.2 Communication

The Communication sub-dimension measures the extent to which a country's Internet users communicate and interact online using their broadband connections. To do so, it uses two indicators: the percentage of Internet users that do video or audio calls using the Internet (Video Calls indicator) and the percentage of Internet users that use social networks (Social Networks indicator).

2.3.3 Transactions

The Transactions sub-dimension captures the propensity of Internet users to perform transactions online. It concentrates on two indicators: whether users go online to fulfil their banking needs (eBanking indicator), or to purchase products or services (Shopping indicator).

2.4 Integration of Digital Technology Dimension

On the business side, digitization is one of the main contributors to enhanced economic growth. Adoption of digital technology (among which are new technologies such as Cloud, Big Data, or the Internet of Things) to enhance efficiency, reduce costs or allow for closer engagement with customers, collaborators or business partners is becoming a mandatory requirement for being competitive. This, together with the ability to use the Internet as a sales outlet, can contribute significantly to the modernisation of businesses and, ultimately, to their success. However, the integration of these technologies in the business sector cannot happen without the appropriate infrastructure, whether it is the availability of fast Internet or the availability of skilled workers in the labour market.

The Integration of Digital Technology dimension is divided into two sub-dimensions.

2.4.1 Business digitization

The Business digitization sub-dimension takes stock of the level of adoption of digital technologies by a country's businesses. It focuses on five technologies: the sharing of information electronically inside companies via ERP (Electronic Information Sharing

indicator), the use of Radio-frequency Identification technologies (RFID indicator), the engagement with clients, partners and other stakeholders via social media (Social Media indicator), the use of e-invoices (eInvoices indicator) and the use of Cloud services of at least medium complexity (Cloud indicator).

2.4.2 eCommerce

The eCommerce sub-dimension focuses on the exploitation of the online sales channel by a country's small and medium enterprises. It captures this via three indicators: the percentage of SMEs that have sold online during the previous year (SMEs Selling Online indicator), the average turnover they realised from online sales (eCommerce Turnover indicator), and the percentage of SMEs that sold online to other EU countries (Selling Online Cross-border indicator).

2.5 Digital Public Services Dimension

Business and citizen interaction with the Public Sector can be improved and made significantly more efficient through the use of digital technologies. Such efficiency gains materialise both on the side of the Public Administration as well as on the business side. Public Administration can take advantage of technology to better address an ever more demanding set of business and citizen needs while at the same time realising significant cost reductions. With better and more streamlined Public Services, citizens and businesses gain in efficiency, both due to more functionality as well as to reductions in time spent. Furthermore, the use of electronic systems in areas such as public procurement or taxation can lead of significant gains by streamlining processes and increasing efficiency, improving transparency, and reducing the room for corruption or evasion. Similarly, developments in eHealth such as the exchange of electronic patient data and the use of ePrescriptions are examples of tools that can greatly improve the efficiency of health systems.

The Digital Public Services dimension is divided into two sub-dimensions.

2.5.1 eGovernment

The eGovernment sub-dimension captures the level of development of a country's eGovernment services. It does so using four indicators: the percentage of Internet users that have engaged with the public administration and exchanged filled forms online (eGovernment Users indicator); the level of sophistication of a country's eGovernment services (using the Pre-filled Forms indicator, which measures the extent to which data that is already known to the public administration is pre-filled in the forms that are presented to the user); the level of completeness of a country's eGovernment offer (using the Online Service Completion indicator, which measures the extent to which the various

steps in an interaction with the public administration – life event – can be performed completely online), and the government commitment to open data (by means of the Open Data indicator).

2.5.2 eHealth

The eHealth sub-dimension captures developments in digitisation of the healthcare sector in a country. It focuses on use of e-health technology by general practitioners, in particular whether they exchange medical data electronically with other health professionals (Medical Data Exchange indicator) and whether they electronically transfer prescriptions to pharmacists (ePrescription indicator).

3 Methodological considerations

3.1 Indicator Requirements

Indicators used in the DESI comply with the following requirements:

- *Must be collected on a regular basis*. In order to fulfil the monitoring function, the indicators used in the index must be collected ideally on a yearly basis (or at least with a pre-defined regularity).
- *Must be relevant for a policy area of interest*. All indicators in the index must be accepted as relevant metrics in their specific policy areas.
- *Must not be redundant*. The index should not contain indicators that are redundant, either statistically or in terms of interpretation.

3.2 Normalisation

In order to aggregate indicators expressed in different units into the sub-dimensions and dimensions of the DESI, those indicators were normalised. In DESI, normalisation was done using the *min-max* method, which consists on a linear projection of each indicator onto a scale between 0 and 1. For indicators with positive direction (i.e., where higher is better), the 0 value in the normalised scale was anchored to the minimum value in the indicator original scale, and the value 1 in the normalised scale was anchored to the maximum value in the indicator's scale. The opposite happened for indicators with negative direction[3].

To allow for inter-temporal comparisons of index scores, the minima and maxima for the normalisation of each indicator were fixed and will be used for normalisation in the future versions of the DESI. Table 2 presents the values that were chosen as the minimum and maximum of each indicator for normalisation purposes.

Due to the choice of normalisation minima and maxima that are fixed over time, the values of one or another indicator may surpass the indicator's normalisation maximum or fall below its minimum in the future. The score for such values will become, respectively, higher than 1 or lower than 0. While this fact does not present a major methodological concern, the choice of minima and maxima was performed carefully taking into account the likely evolution of each indicator and the balance between indicators, so as to try to minimise the occurrence of such events.

[3] In DESI there is one indicator with negative direction: 1d1 Fixed BB Price.

Indicator	Unit	Min	Max
1a1 Fixed BB Coverage	% households	80%	100%
1a2 Fixed BB Take-up	% households	50%	100%
1b1 Mobile BB Take-up	Subscribers per 100 people	25	150
1b2 Spectrum	% of the target	25%	100%
1c1 NGA Coverage	% households	0%	100%
1c2 Subscriptions to Fast BB	% of subscriptions >= 30Mbps	0%	75%
1d1 Fixed BB Price	Percentage of individual gross income (EUR PPP)	0%	4%
2a1 Internet Users	% individuals	40%	100%
2a2 Basic Digital Skills	% individuals	0%	100%
2b1 ICT Specialists	% individuals	0%	5%
2b2 STEM Graduates	Graduates in STEM per 1000 individuals (20-29 yo)	0	40
3a1 News	% individuals who used Internet in the last 3 months	33%	100%
3a2 Music, Videos and Games	% individuals who used Internet in the last 3 months	20%	100%
3a3 Video on Demand	% households with a TV	0%	100%
3a4 IPTV	% households with a TV	0%	75%
3b1 Video Calls	% individuals who used Internet in the last 3 months	20%	100%
3b2 Social Networks	% individuals who used Internet in the last 3 months	40%	100%
3c1 Banking	% individuals who used Internet in the last 3 months	0%	100%
3c2 Shopping	% internet users (last year)	0%	100%
4a1 Electronic Information Sharing	% enterprises	0%	50%
4a2 RFID	% enterprises	0%	15%
4a3 Social Media	% enterprises	0%	50%
4a4 eInvoices	% enterprises	0%	50%
4a5 Cloud	% enterprises	0%	50%
4b1 SMEs Selling Online	% of SMEs	0%	33%
4b2 eCommerce Turnover	% turnover	0%	33%
4b3 Selling Online Cross-border	% of SMEs	0%	25%
5a1 eGovernment Users	% internet users (last year)	0%	80%
5a2 Pre-filled Forms	Score (0 to 100)	0	100
5a3 Online Service Completion	Score (0 to 100)	0	100
5a4 Open Data	Score (0 to 700)	0	700
5b1 Medical Data Exchange	% general practitioners	0%	100%
5b2 ePrescription	% general practitioners	0%	100%

Table 2. Minima and Maxima used in indicator normalisation

3.3 Imputation of missing observations

Some indicators presented missing observations for some countries. Those values were estimated using the imputation package Amelia II[4]. The estimation process ran for each indicator with missing observations, taking as input the set of indicators for which the squared correlation with the indicator with missing observations was the highest.

In DESI 2015, there were 21 missing observations overall, which corresponds to 2.2% of all observations (overall total of 957 observations). The indicator with the highest number of missing observations was *4a4 eInvoices*, with 6 missing values (21% of the total 29 observations).

Table 3 presents the list of missing observations in DESI 2015 and the values resulting from the estimation process.

Indicator	Country	Estimated value
1a2 Fixed BB Take-up	NL	76.8%
1d1 Fixed BB Price	MT	1.7%
2b1 ICT Specialists	HR	2.2%
3a3 Video on Demand	BG	25.5%
	HR	34.1%
4a3 Social Media	CZ	15.1%
	UK	18.5%
	BE	21.3%
	FR	21.8%
4a4 eInvoices	FR	8.0%
	HU	8.5%
	SK	8.8%
	EL	9.1%
	PL	14.8%
	FI	27.5%
4b2 eCommerce Turnover	PL	2.6%
	SI	6.5%
	FI	7.8%
	EL	12.0%
	BE	12.8%
4b3 Selling Online Cross-border	DE	14.2%

Table 3. Estimated values for missing observations in DESI 2015

[4] James Honaker and Gary King and Matthew Blackwell, "Amelia II: A Program for Missing Data", Journal of Statistical Software, Vol. 45, Issue 7, Dec 2011. http://www.jstatsoft.org/v45/i07/

3.4 Weights

Some dimensions, sub-dimensions and individual indicators are more relevant than others, and for such a reason they were given higher weight in the computation of the final index score for each country.

Table 4 presents the overall weights attributed to the main DESI dimensions, which reflect the EU's digital policy priorities. Section 4.4 presents the results of sensitivity analysis performed on the weights attributed to each of the five main DESI dimensions.

Dimension	Weight
1 Connectivity	25%
2 Human Capital	25%
3 Use of Internet	15%
4 Integration of Digital Technology	20%
5 Digital Public Services	15%

Table 4. Weights attributed to the DESI dimensions

Connectivity and *Human Capital* can be considered the most relevant dimensions because they represent the infrastructure of the digital economy and society. Hence, they were given higher weights. *Integration of Digital Technology* captures the use of ICT by the business sector, which, according to growth accounting theories is one of the most important drivers of growth. It was given a high weight, but not as high as the previous two dimensions. Finally, *Use of Internet* (by citizens) and *Digital Public Services* are enabled by the infrastructure and their contribution is strengthened by the quality of such infrastructure. For this reason, they were weighed less.

Weights were also assigned at the sub-dimension and individual indicator level. Weights used at the sub-dimension level are summarised in table 5[5].

Within *Connectivity*, *Fixed Broadband* and *Speed* are considered to be the most important sub-dimensions (weighted 33%), followed by *Mobile Broadband* (23%) and then by *Affordability* (11%). All the sub-dimensions within the *Human Capital* and *Use of Internet* dimensions are considered of equal importance and are therefore weighted equally. When it comes to *Integration of Digital Technology*, the *Business Digitisation* dimension is more important than the *eCommerce* one, and therefore weighted higher at 60%. The same

[5] Since the weight assignment for sub-dimensions is local to the dimension that they are part of, then the sum of weights of the sub-dimensions within each dimension should add up to 100%.

happens within the *Digital Public Services* dimension, where *eGovernment* is weighted at 67%, versus 33% for *eHealth*.

Sub-Dimension		Weight
1 Connectivity		
	1a Fixed Broadband	33%
	1b Mobile Broadband	22%
	1c Speed	33%
	1d Affordability	11%
2 Human Capital		
	2a Basic Skills and Usage	50%
	2b Advanced skills and Development	50%
3 Use of Internet		
	3a Content	33%
	3b Communication	33%
	3c Transactions	33%
4 Integration of Digital Technology		
	4a Business digitization	60%
	4b eCommerce	40%
5 Digital Public Services		
	5a eGovernment	67%
	5b eHealth	33%

Table 5. Weights attributed to the DESI sub-dimensions

For simplicity, all individual indicators within each sub-dimension were considered of equal importance and therefore weighted equally within the respective sub-dimension.

3.5 Method of Aggregation

In DESI, the aggregation of indicators into sub-dimensions, of sub-dimensions into dimensions, and of dimensions into the overall index was performed from the bottom up using simple weighted arithmetic averages following the structure of the index (table 1).

As an example, the top-level DESI score for country C was calculated using the formula:

$$DESI(C) = Connectivity(C) * 0.25 + Human\_capital(C) * 0.25 + Use\_of\_Internet(C) * 0.15 + Integration\_of\_Digital\_Technology(C) * 0.2 + Digital\_Public\_Services(C) * 0.15$$

Where $Connectivity(C)$ is the score obtained by country C in the Connectivity dimension, and so on for the remaining dimensions in the formula.

4 Main Results and Robustness Analysis

4.1 DESI 2015 ranking

Figure 1 depicts the main ranking of countries in the DESI 2015. DESI scores range from 0 (worst) to 1 (best). The height of each bar in the chart corresponds to the score achieved by the corresponding country, and the height of each colour within the bar corresponds to the contribution of the corresponding dimension to the overall score (taking into account the weight attributed to the dimension).

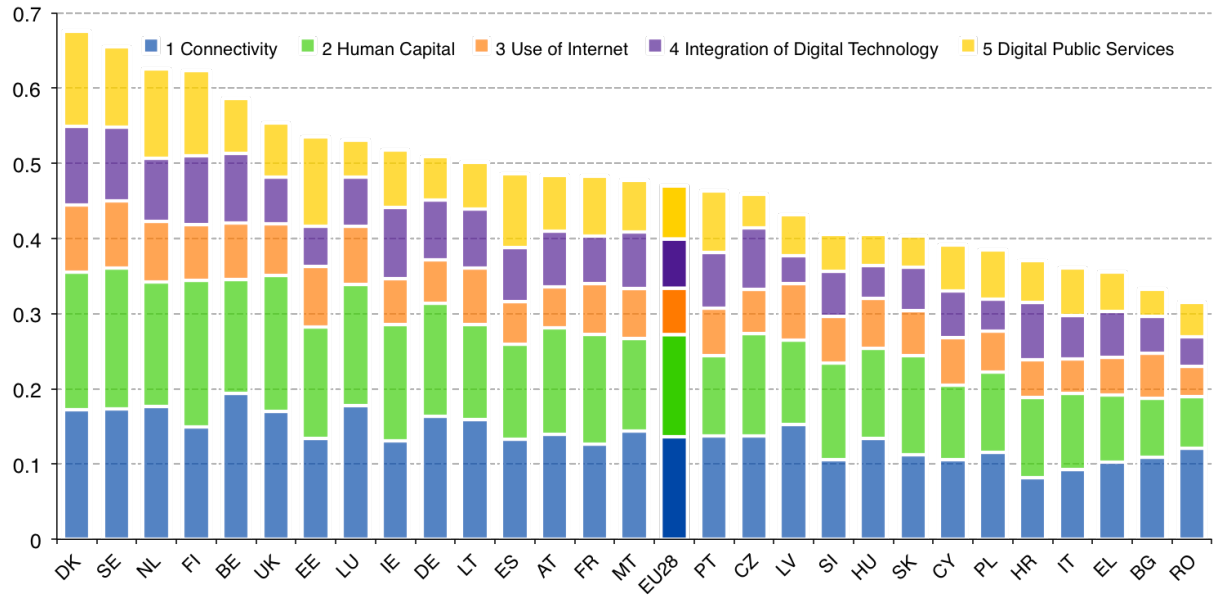


Figure 1. DESI 2015 main ranking

In DESI 2015, the best performing country was Denmark with a score of 0.68 and the worst performing country was Romania with a score of 0.31.

Nordic countries (and the Netherlands) performed quite well, taking the top positions in the ranking and scoring above 0.6.

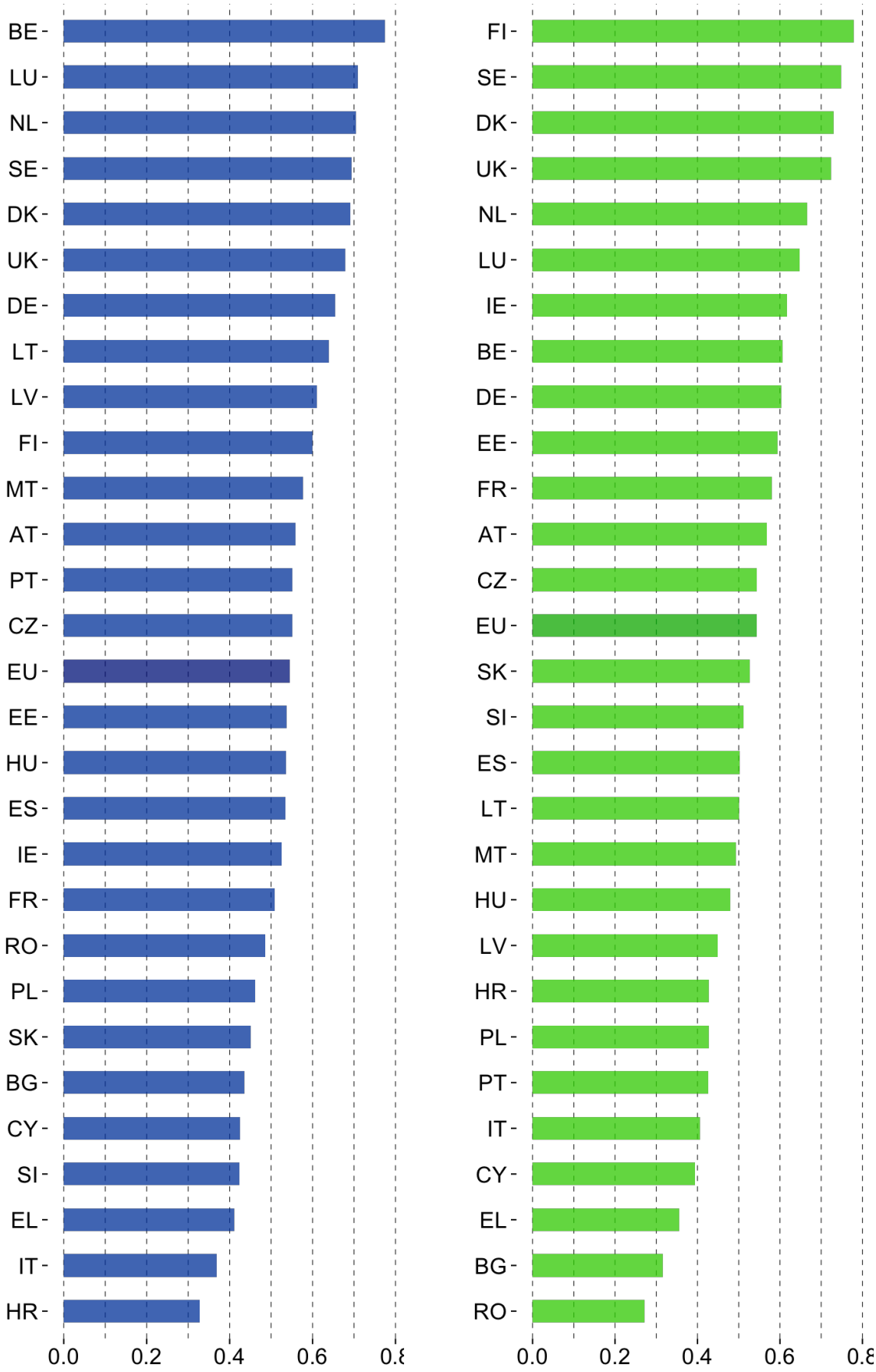
Overall, 11 countries were able to score above the middle of the scale (above 0.5), and 15 countries scored better than the EU average (0.47).

Table 6 presents the scores and ranking positions for all countries in the DESI and in each of the five main dimensions. Charts in sections 4.1.1 through 4.1.6 present the ranking of countries in each main DESI dimension and in sub-dimensions thereunder.

	DESI		1 Connectivity		2 Human Capital		3 Use of Internet		4 Integration of Digital Technology		5 Digital Public Services	
	score	**rank**	score	rank	score	rank	score	rank	score	rank	score	rank
DK	**0.68**	**1**	0.69	5	0.73	3	0.60	2	0.52	1	0.84	1
SE	**0.66**	**2**	0.69	4	0.75	2	0.60	1	0.49	2	0.71	5
NL	**0.63**	**3**	0.71	3	0.67	5	0.53	4	0.42	6	0.79	3
FI	**0.62**	**4**	0.60	10	0.78	1	0.50	9	0.45	5	0.76	4
BE	**0.59**	**5**	0.77	1	0.61	8	0.51	6	0.46	4	0.48	12
UK	**0.55**	**6**	0.68	6	0.72	4	0.46	10	0.31	17	0.49	11
EE	**0.54**	**7**	0.54	15	0.59	10	0.54	3	0.27	23	0.79	2
LU	**0.53**	**8**	0.71	2	0.65	6	0.51	5	0.33	15	0.33	23
IE	**0.52**	**9**	0.53	18	0.62	7	0.41	17	0.47	3	0.51	9
DE	**0.51**	**10**	0.65	7	0.60	9	0.38	21	0.40	8	0.39	18
LT	**0.50**	**11**	0.64	8	0.50	17	0.50	7	0.39	9	0.41	16
ES	**0.49**	**12**	0.53	17	0.50	16	0.38	22	0.36	14	0.65	6
AT	**0.48**	**13**	0.56	12	0.57	12	0.36	24	0.37	13	0.50	10
FR	**0.48**	**14**	0.51	19	0.58	11	0.46	11	0.31	16	0.53	8
MT	**0.48**	**15**	0.58	11	0.49	18	0.44	13	0.38	11	0.46	13
EU	**0.47**		0.55		0.54		0.41		0.33		0.47	
PT	**0.46**	**16**	0.55	13	0.43	23	0.42	15	0.37	12	0.55	7
CZ	**0.46**	**17**	0.55	14	0.54	13	0.39	20	0.41	7	0.30	25
LV	**0.43**	**18**	0.61	9	0.45	20	0.50	8	0.19	28	0.36	20
SI	**0.41**	**19**	0.42	25	0.51	15	0.41	16	0.30	20	0.33	22
HU	**0.41**	**20**	0.54	16	0.48	19	0.45	12	0.22	25	0.27	26
SK	**0.40**	**21**	0.45	22	0.53	14	0.40	18	0.29	21	0.27	27
CY	**0.39**	**22**	0.43	24	0.39	25	0.42	14	0.31	18	0.41	17
PL	**0.38**	**23**	0.46	21	0.43	22	0.36	23	0.21	26	0.43	14
HR	**0.37**	**24**	0.33	28	0.43	21	0.34	25	0.38	10	0.38	19
IT	**0.36**	**25**	0.37	27	0.41	24	0.31	27	0.29	22	0.42	15
EL	**0.36**	**26**	0.41	26	0.36	26	0.33	26	0.31	19	0.35	21
BG	**0.33**	**27**	0.44	23	0.32	27	0.40	19	0.24	24	0.24	28
RO	**0.31**	**28**	0.49	20	0.27	28	0.27	28	0.19	27	0.31	24

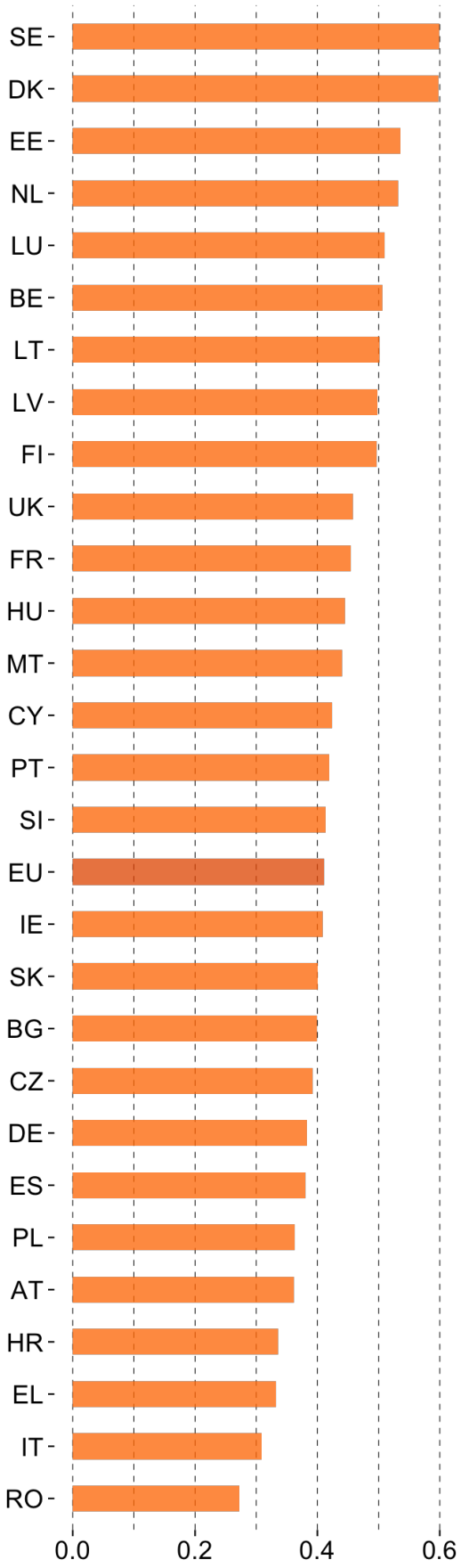
Table 6. Scores and ranking positions in DESI 2015 (overall index and dimensions)

4.1.1 DESI 2015 Dimension Rankings

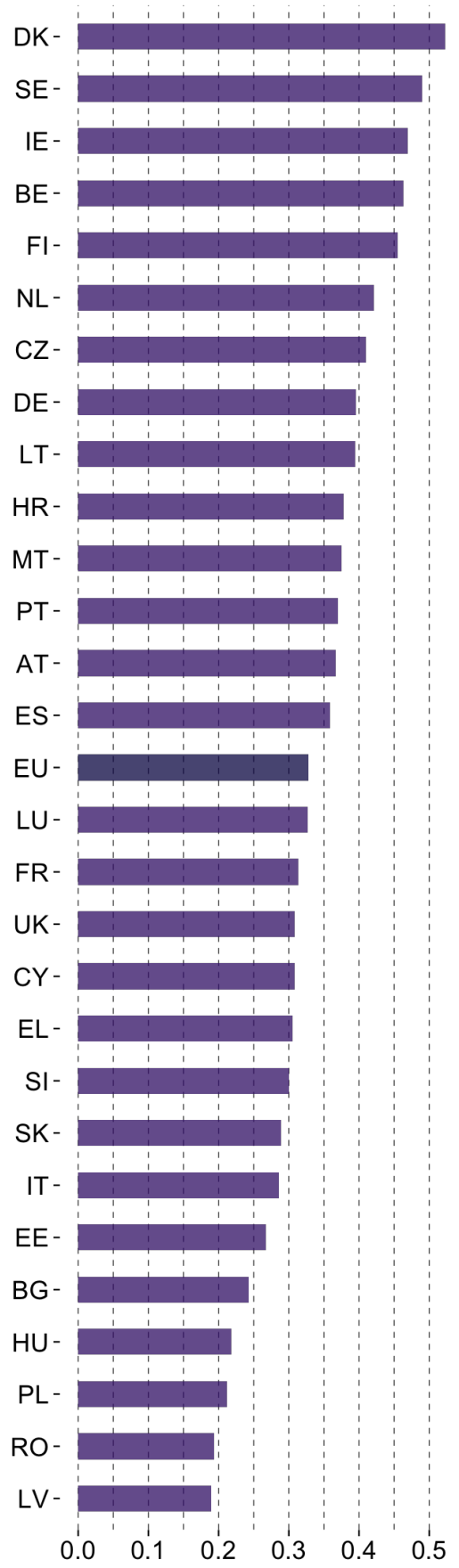


1 Connectivity

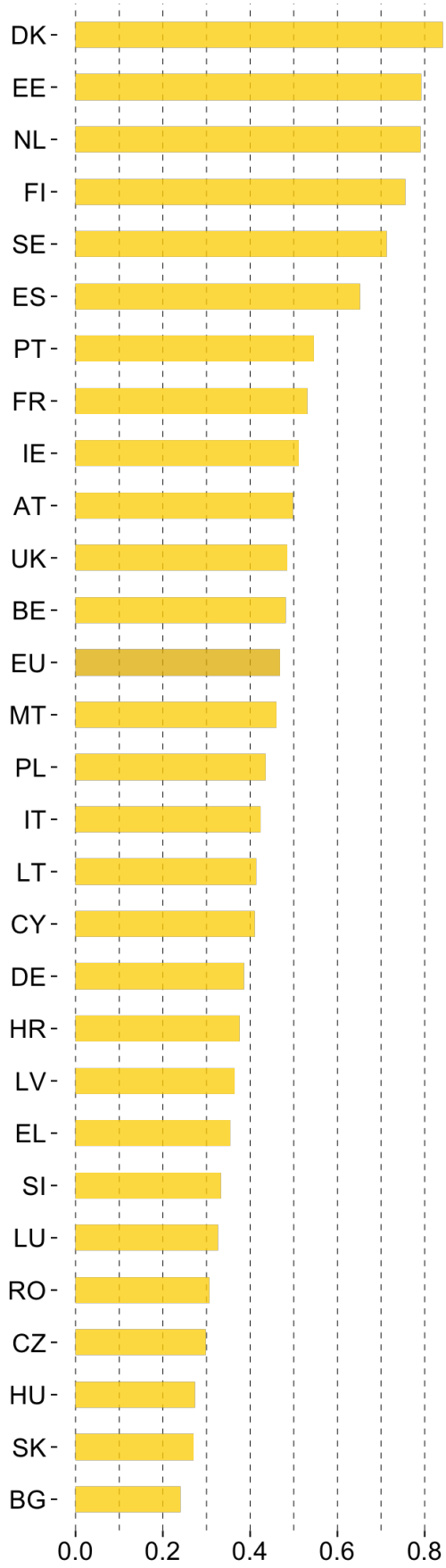
2 Human Capital



3 Use of Internet

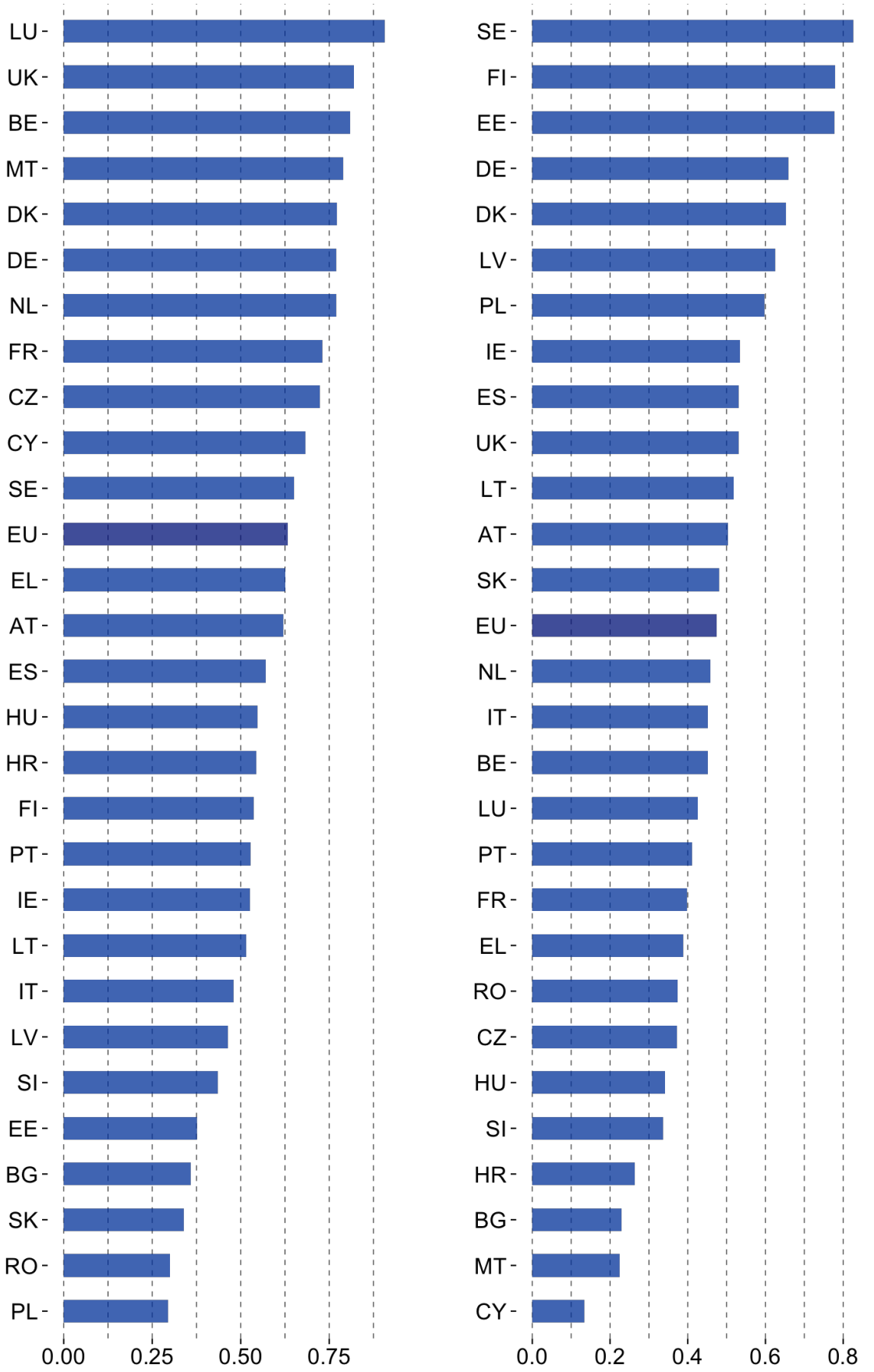


4 Integration of Digital Technology



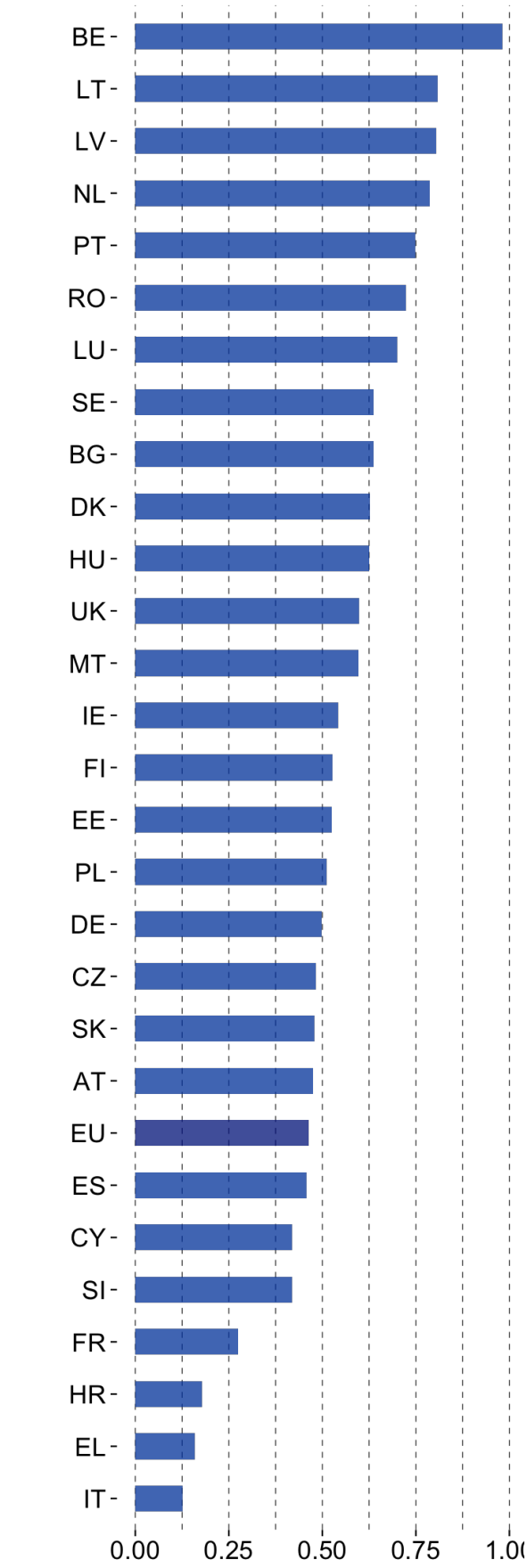
5 Digital Public Services

4.1.2 DESI 2015 Connectivity sub-dimension rankings

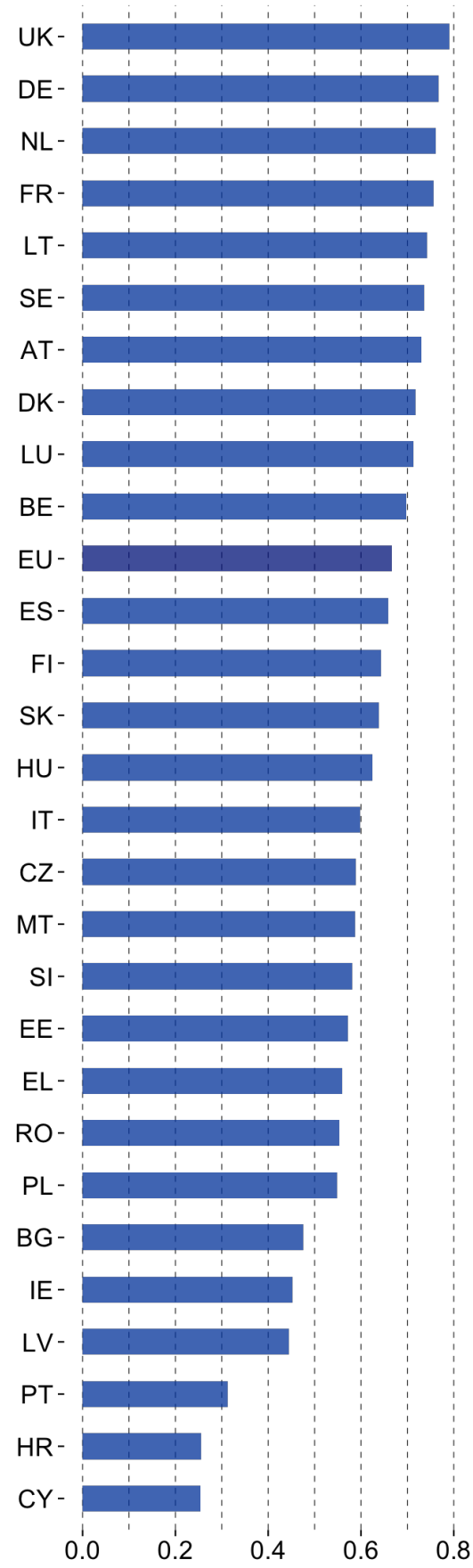


1a Fixed Broadband

1b Mobile Broadband

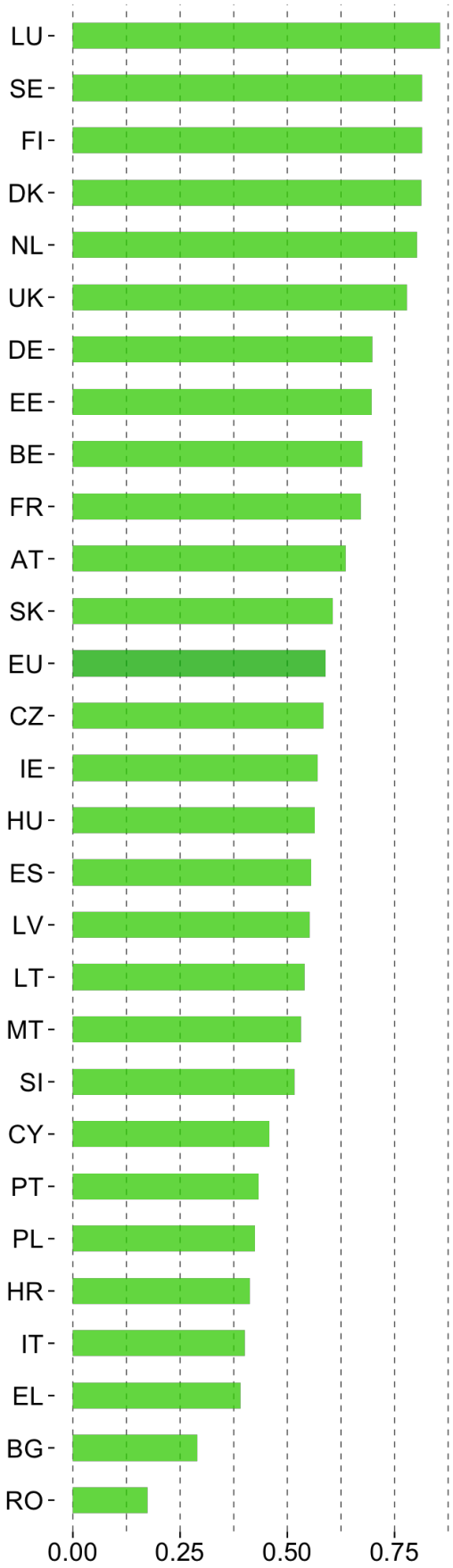


1c Speed

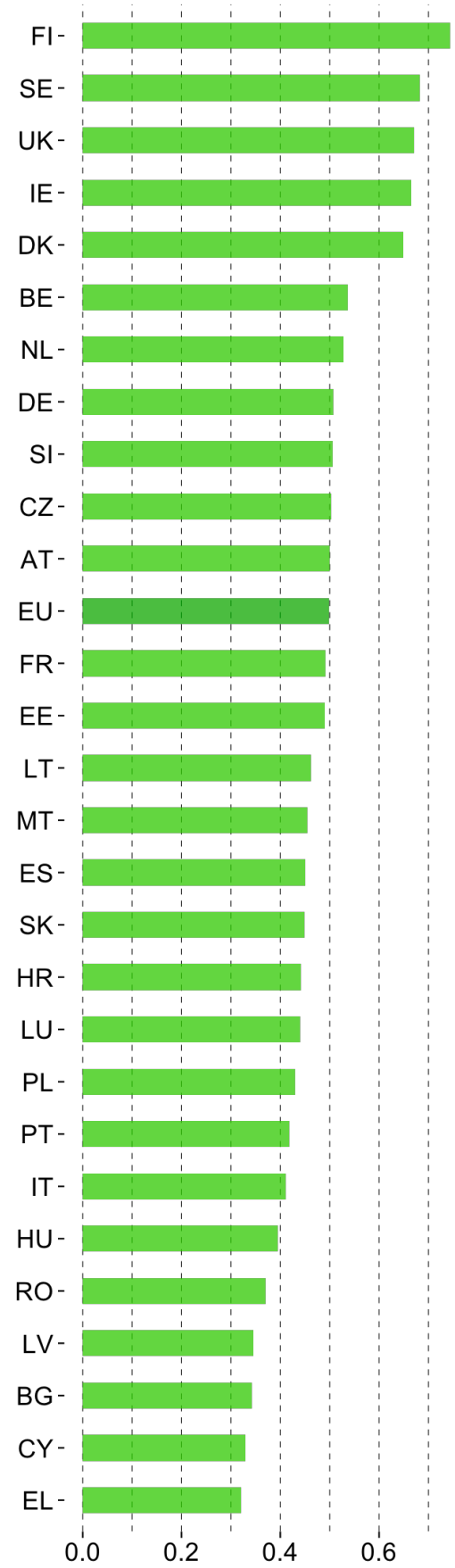


1d Affordability

4.1.3 DESI 2015 Human Capital sub-dimension rankings

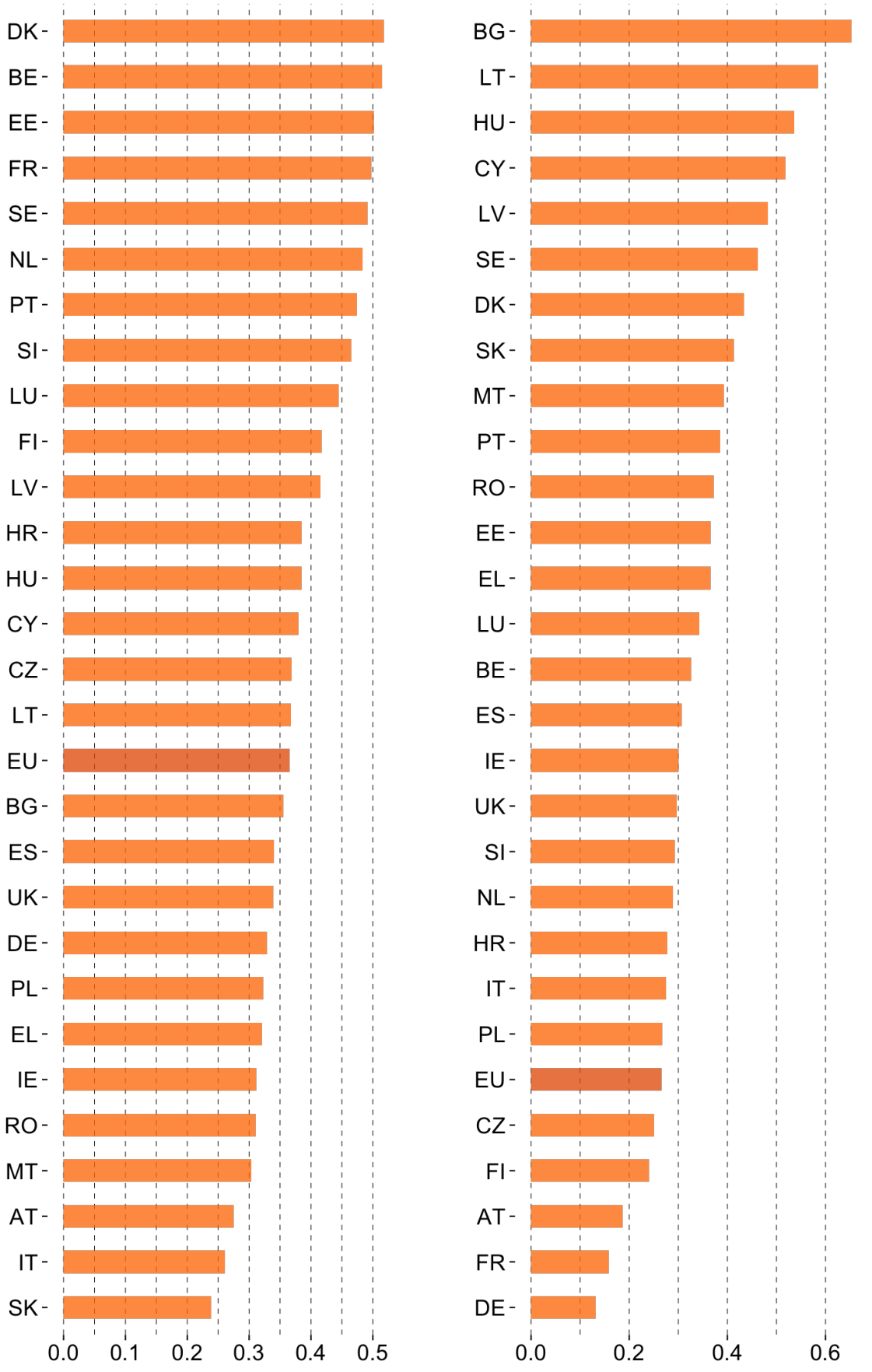


2a Basic Skills and Usage



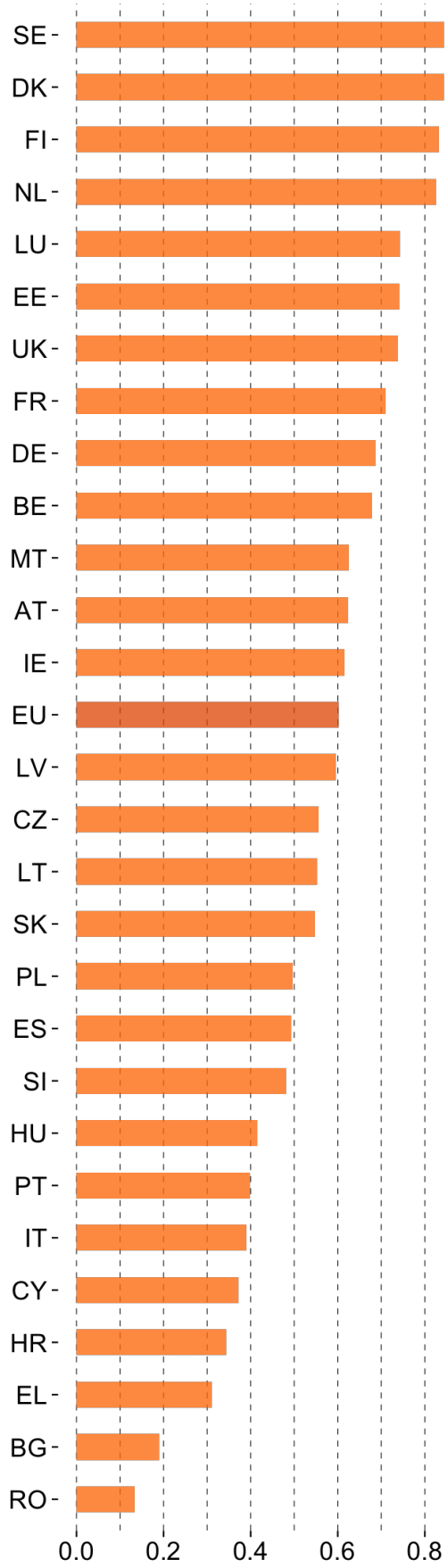
2b Advanced Skills and Development

4.1.4 DESI 2015 Use of Internet sub-dimension rankings



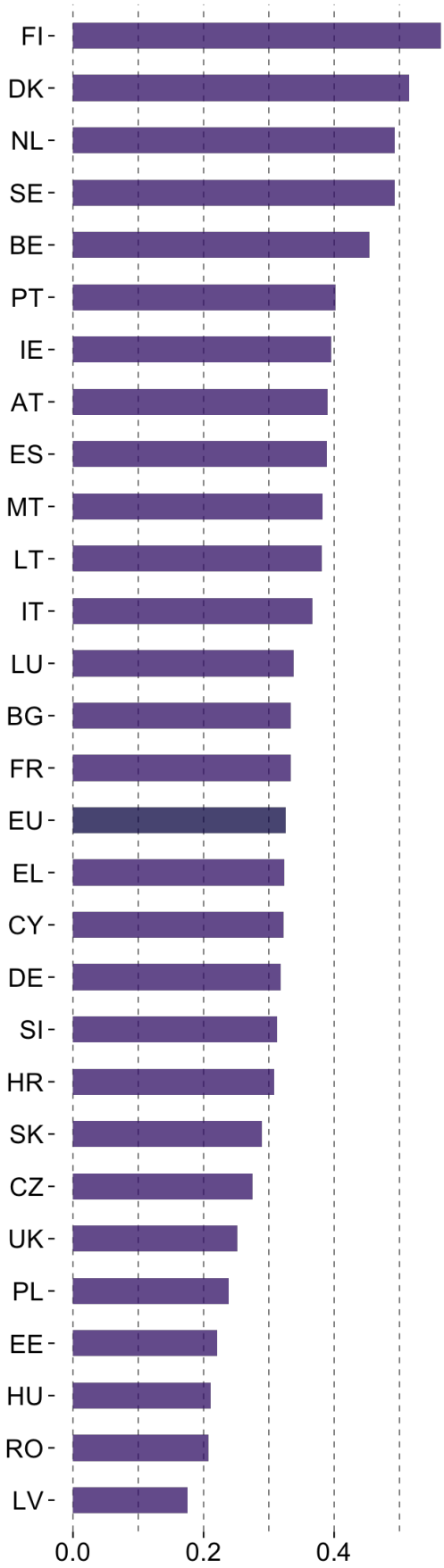
3a Content

3b Communication

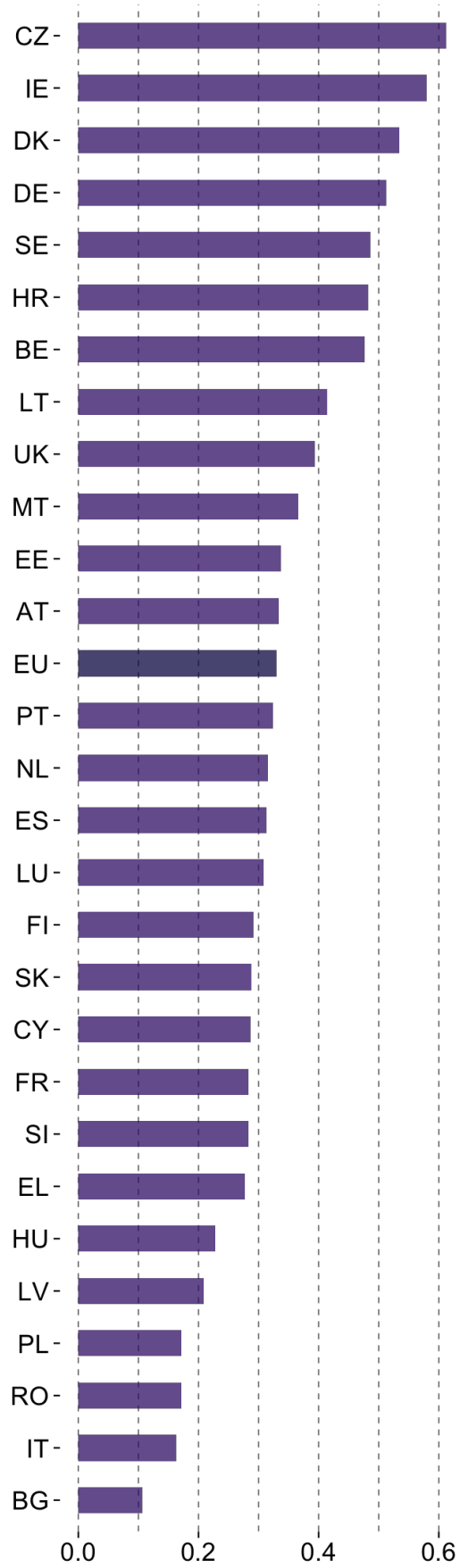


3c Transactions

4.1.5 DESI 2015 Integration of Digital Technology sub-dimension rankings

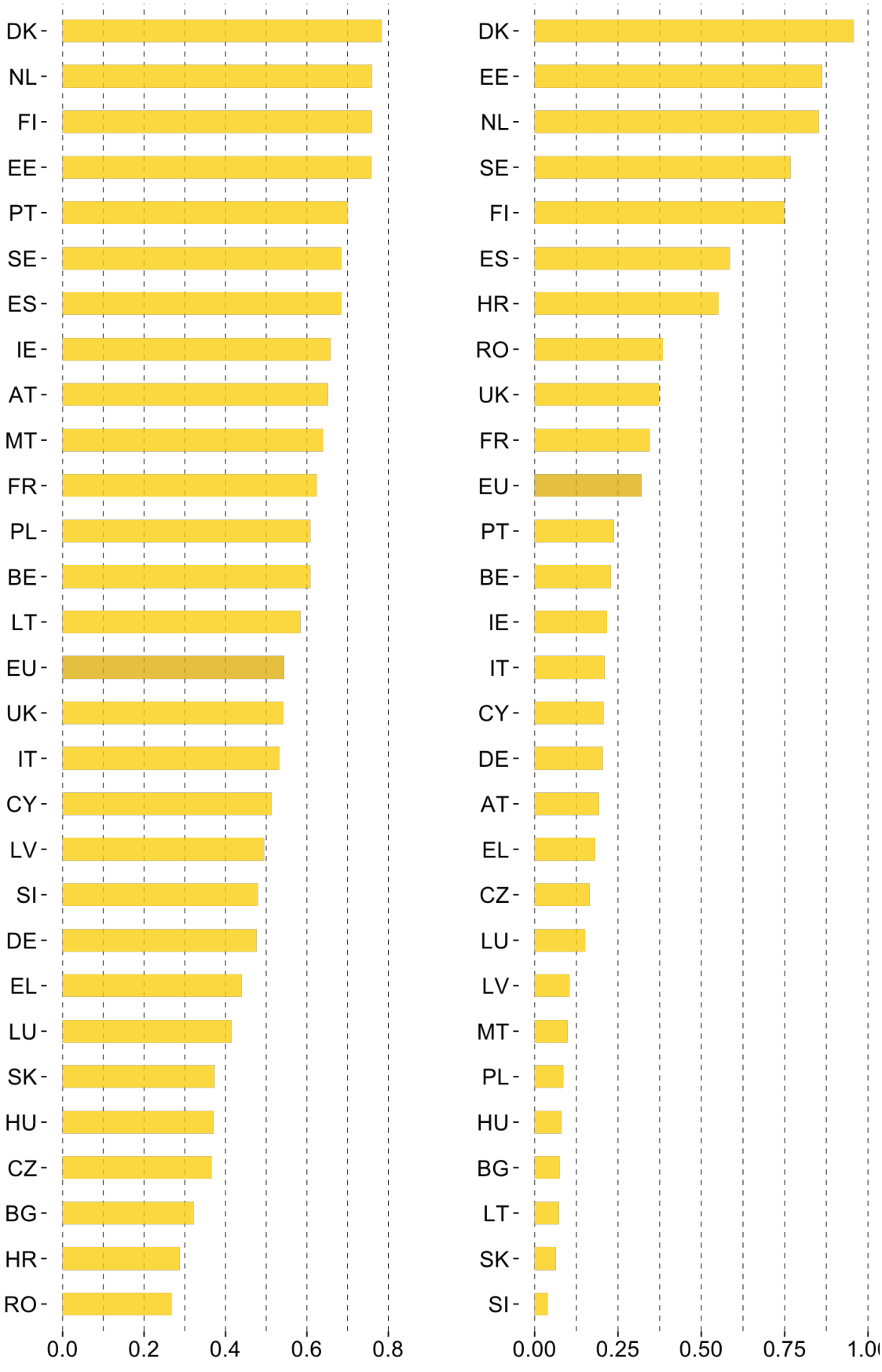


4a Business Digitisation



4b eCommerce

4.1.6 DESI 2015 Digital Public Services sub-dimension rankings



5a eGovernment

5b eHealth

4.2 Clustering

Countries were grouped into clusters according to their performance in the five main DESI dimensions. The clustering algorithm used was a general agglomerative hierarchical clustering algorithm based on Ward's method, using a dissimilarity matrix based on Euclidean distances. The number of clusters was selected using the method of Mojena[6] with a *k* parameter of 1.25[7]. The result was the three-cluster configuration portrayed in figure 2.

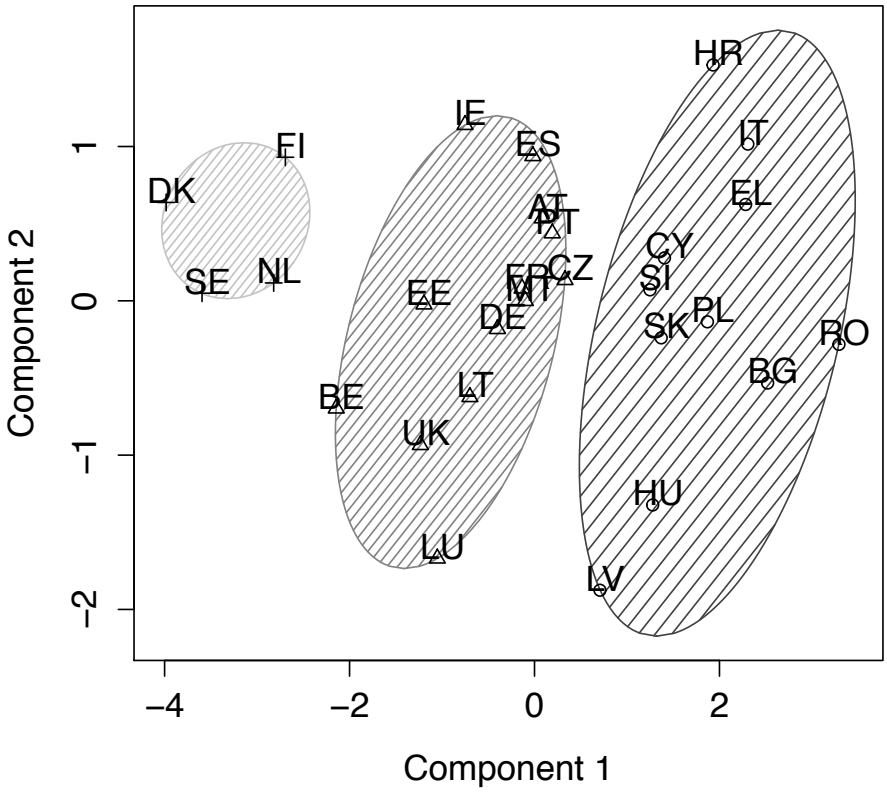


Figure 2. Cluster plot against two principal components
(principal components explain 82% of the point variability)

Table 7 presents the average scores obtained in the DESI and in each of the five principal dimensions by the countries in each cluster.

[6] R. Mojena. "Hierarchical grouping methods and stopping rules: an evaluation". The Computer Journal (1977) 20 (4): 359-363

[7] Glenn W. Milligan, Martha C. Cooper. "An examination of procedures for determining the number of clusters in a data set", Psychometrika (1985) 50(2): 159

	Low performance	Medium performance	High performance
DESI	0.38	0.51	0.65
1 Connectivity	0.45	0.60	0.67
2 Human Capital	0.42	0.57	0.73
3 Use of Internet	0.38	0.44	0.56
4 Integration of Digital Technology	0.27	0.37	0.47
5 Digital Public Services	0.34	0.49	0.77

Table 7. Average scores within clusters

In light of the scores of the countries included in each cluster, the clusters were labelled "low performance", "medium performance" and "high performance":

- Denmark, Sweden, The Netherlands and Finland belong to the high performance cluster. They are not only ahead in the EU, but they are world leaders in digital.
- Belgium, the United Kingdom, Estonia, Luxembourg, Ireland, Germany, Lithuania, Spain, Austria, France, Malta, Portugal and the Czech Republic belong to the medium-performance cluster. They are doing well in certain areas but still need to progress in others.
- Latvia, Slovenia, Hungary, Slovakia, Cyprus, Poland, Croatia, Italy, Greece, Bulgaria and Romania belong to the low performance cluster. They need to step up their performance in a number of areas and catch up with the rest of the EU.

4.3 Intra- and Inter-dimension variability

Digital development is uneven across the EU, even if there was some convergence in the performance of countries from 2014 to 2015. This can be seen in table 8, which presents the coefficient of variation (CV) calculated for the country scores in the overall DESI and in each of the five main dimensions.

	DESI 2014	DESI 2015
DESI	22.2	20.7
1 Connectivity	21.2	20.8
2 Human Capital	26.2	24.7
3 Use of Internet	21.0	18.9
4 Integration of Digital Technology	27.3	26.5
5 Digital Public Services	39.3	36.5

Table 8. Coefficient of variation (CV) across Member States

The coefficient of variation across member states' DESI scores in 2015 was 20.7, slightly lower than in 2014, where it was 22.2. This means that there was a slight convergence in country performance. Nevertheless, in 2015 the span between the score of the best overall performer (DK: 0.68) and the worst overall performer (RO: 0.31) was 0.37.

From the five main DESI dimensions, Digital Public Services is where country performance is more uneven in 2015 (CV of 36.5). In this dimension, the distance between Denmark (score: 0.84) and Bulgaria (score: 0.24) is a staggering 0.6 (i.e., more than half of the DESI scale). On the converse side, countries perform more coherently in the Use of Internet dimension (CV of 18.9), where there is a span of 0.33 between the score of the best performer (SE: 0.6) and that of the worst performer (RO: 0.27).

Performance is also uneven across the main DESI dimensions for each individual country. Table 9 reports on the coefficient of variation (CV) for the scores obtained in the five main DESI dimensions by each country in DESI 2014 and DESI 2015. Lower figures indicate that a country has a better balance in its scores across dimensions.

	DESI 2014	DESI 2015		DESI 2014	DESI 2015
HR	13.4	10.8	**NL**	27.2	23.4
EL	10.4	11.1	**FI**	29.6	23.8
CY	16.3	12.5	**CZ**	21.9	24.5
IE	20.0	15.2	**ES**	26.5	24.7
MT	16.1	15.8	**PL**	27.0	26.5
SE	21.2	16.1	**BG**	27.5	27.2
IT	24.1	16.8	**DE**	25.8	27.5
PT	20.9	17.7	**SK**	23.7	28.0
DK	24.6	18.1	**UK**	32.4	32.1
LT	14.3	19.8	**EE**	38.8	34.4
SI	21.3	21.0	**LU**	30.7	35.2
AT	25.7	21.4	**HU**	32.0	35.3
FR	23.8	21.4	**RO**	39.1	35.6
BE	20.2	22.7	**LV**	34.1	37.4

Table 9. Coefficient of variation (CV) across scored in the five main DESI 2015 dimension

The table shows that most countries have improved the balance of their performance over the last year, with only 9 countries increasing their coefficient of variation.

However, there are countries for which digital development is not happening in all fronts. Countries like Latvia, Romania, Hungary and Luxemburg, for instance, obtain high scores in Connectivity, but significantly lower scores in the other dimensions, which indicates that their investment in broadband infrastructure is not being matched by investment in other areas that allow them to take advantage of that infrastructure for economic development.

4.4 Sensitivity to changes in weights

The score and rank position of countries depends to an extent on the relative importance that is given to different dimensions and indicators comprising the DESI. The dimension and sub-dimension weights used in the DESI were selected to represent the EU's digital policy priorities. However, different sets of weights would yield different DESI rankings[8]. Through simulation, it is possible to conclude that shifting the weights of the five main DESI dimensions within reasonable boundaries does not radically change the configuration of the DESI results.

For the purposes of this simulation, each dimension's weight was allowed to vary between 1 and 5 by unitary increments, thus achieving a set of 3125 weight configurations (which were then normalised to add up to 100%). Configurations that would allow one dimension to overwhelm all the others, i.e., where one dimension's weight was more than the double of the highest weight among the other dimensions, were discarded. The DESI scores and rankings were calculated for each of the remaining 3001 unique normalised weight configurations, yielding a distribution of 3001 scores and ranking positions for each country.

Table 10 presents the summary of simulation results in the form of the average (for all countries) of the maximum decrease in score obtained by each country relative to its DESI score, and the maximum increase in score relative to the DESI score. It presents also the average 5th percentile in the score distribution and the average 95th percentile in the score distribution. The table also presents similar figures, but for ranking positions.

	Score	Rank
Decrease (maximum)	-0.07	-3
Decrease (5th percentile)	-0.04	-2
Increase (95th percentile)	0.03	2
Increase (maximum)	0.05	4

Table 10. Variation in scores and ranks (averages across all countries)

On average, the score obtained by countries can vary between a decrease of 0.07 and an increase of 0.05 under different weight configurations, but in fact, 90% of the weight configurations yield a variation that does, on average, not go beyond a decrease of 0.04 or

[8] DG CNECT makes available the online DESI simulation tool (http://ec.europa.eu/digital-agenda/en/digital-agenda-scoreboard), which allows users to select their preferred weights and observe the effects in the DESI overall scores and ranking.

an increase of 0.03. In terms of raking positions, 90% of the weight configurations keep countries within an average of plus or minus two ranks from their DESI ranking.

These average variations in scores and ranks differ from country to country, since some countries' scores and ranks are more sensitive to the weights used than others. Figures 3 and 4 present the variation in scores and ranks for individual countries obtained from the simulated weight configurations. In the figures, the darker red and darker blue bars represent the 5th and 95th percentiles of the distribution of scores (or ranks in figure 4) for each country, whereas the lighter red and lighter blue bars extend all the way to the minimum and maximum scores (and ranks) in the distribution. All values are anchored to the score (or rank) obtained by the country in the DESI 2015.

Figure 3 shows that, in 90% of the weight configurations, most countries maintain their score within +0.05/-0.05 of their DESI 2015 score. Considering the entire set of weight configurations, the vast majority of countries maintain their score within +0.1/-0.1 of their DESI 2015 score.

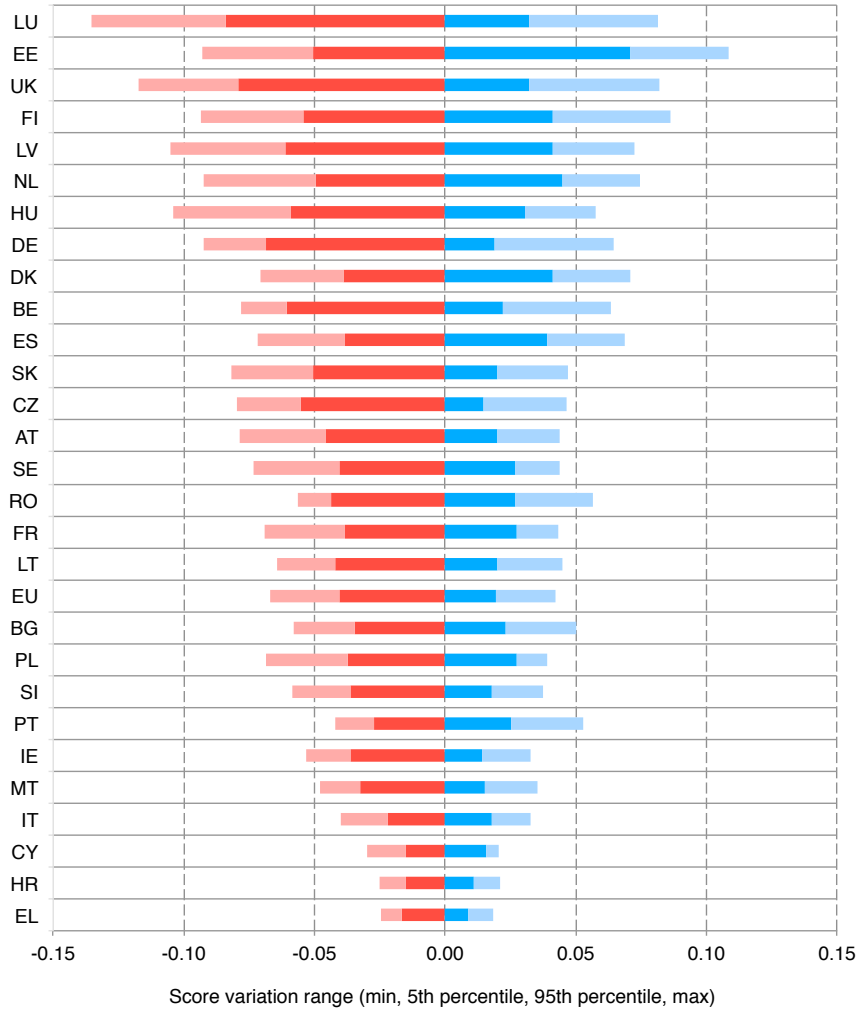


Figure 3. Score variation from weight changes in the 5 main DESI 2015 dimensions

However, rankings are more sensitive to changes in weights. Figure 4 shows that, while countries at the top of the ranking (Denmark, Sweden, the Netherlands, Finland) and at the bottom of the ranking (Romania, Bulgaria, Greece) would not change their ranking significantly under different weight configurations, countries in the middle of the ranking (like Latvia, Spain, Estonia, Portugal or Luxemburg) can be more sensitive to the weight configuration (for instance, from the 5th to the 95th percentiles of the rank distributions, Portugal could go from climbing 5 positions to falling 1 position in the ranking, and Luxemburg could go from climbing 1 position to falling 7 positions).

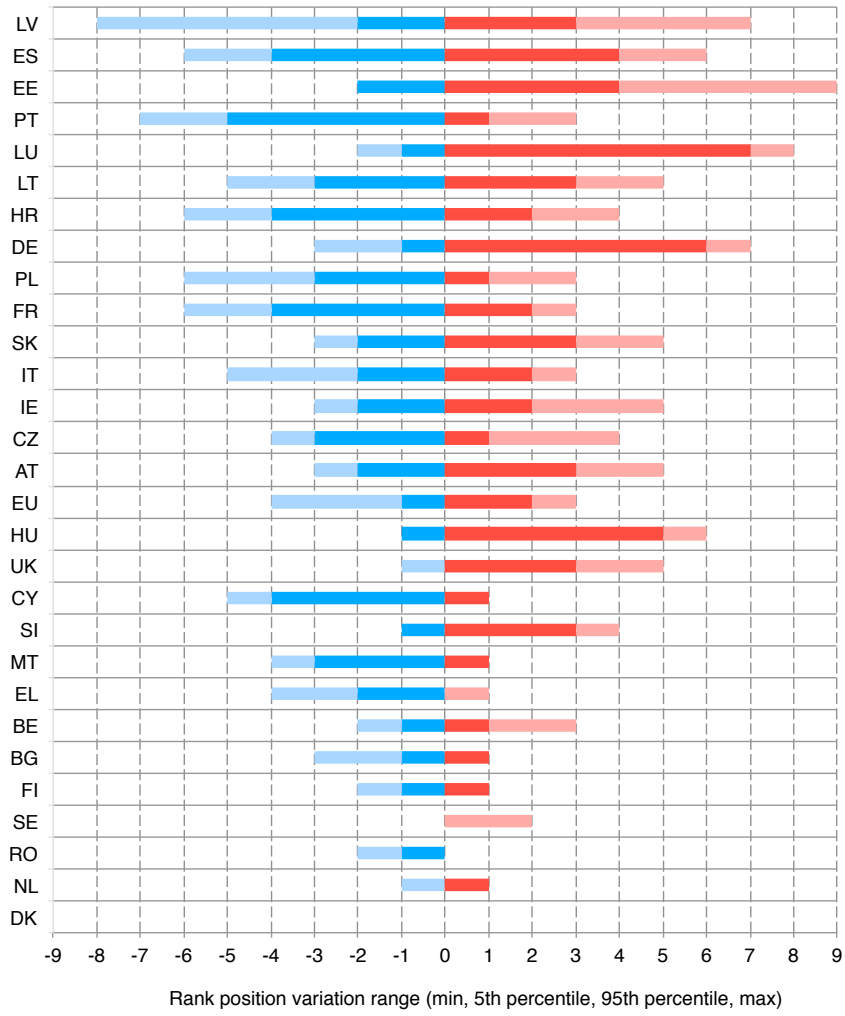


Figure 4. Rank variation from weight changes in the 5 main DESI 2015 dimensions

Annex I.

Detailed Description of Indicators comprised in the DESI

1a1 Fixed BB Coverage

Description:
Standard fixed broadband coverage

Breakdown:
All households

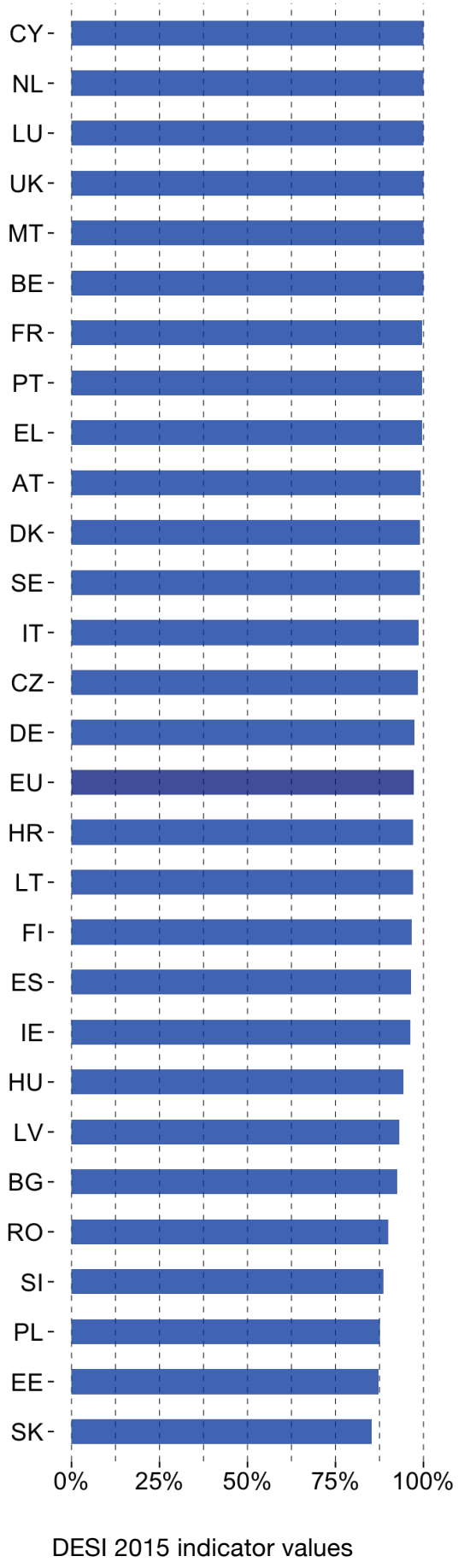
Unit:
% households

Source:
Broadband coverage in Europe, studies for the EC by Point Topic (2011-2012 figures, SMART 2011/0027 and 2012/0035) and IHS and Valdani, Vicari & Associati (2013 figures, SMART 2013/0054)

Calculation:
no further calculation

DESI 2014: data from December 2013

DESI 2015: data from December 2013



DESI 2015 indicator values

1a2 Fixed BB Take-up

Description:
Households that have a fixed Broadband connection

Breakdown:
All households

Unit:
% households

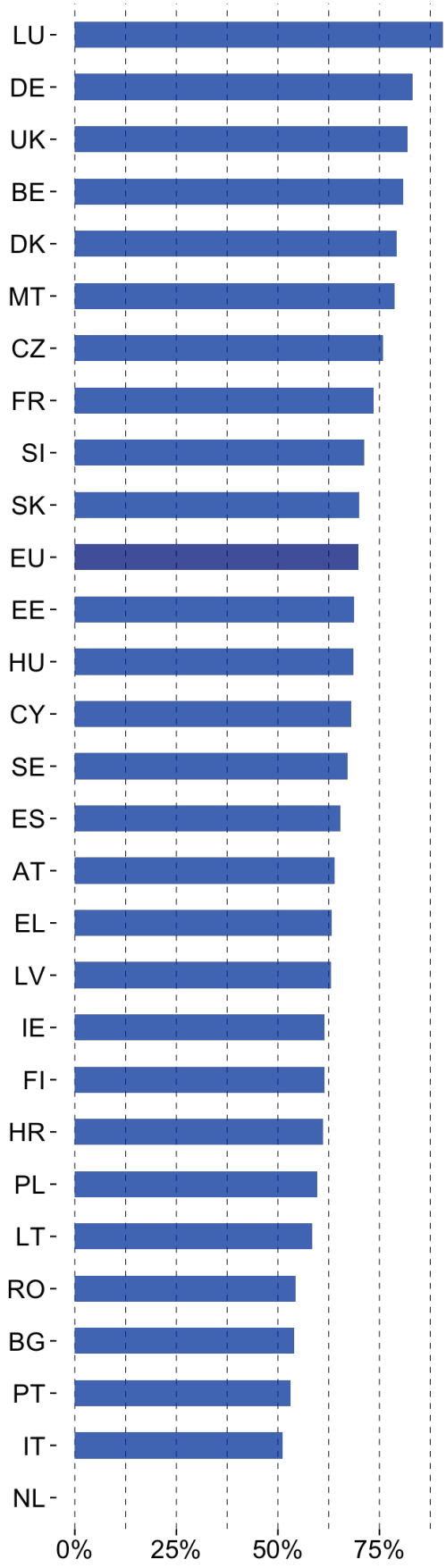
Source:
Eurostat - Community survey on ICT usage in Households and by Individuals

Calculation:

no further calculation

DESI 2014: data from December 2013

DESI 2015: data from December 2014



DESI 2015 indicator values

1b1 Mobile BB Take-up

Description:
Mobile Broadband Take-up

Breakdown:
All subscriptions

Unit:
Subscribers per 100 people

Source:

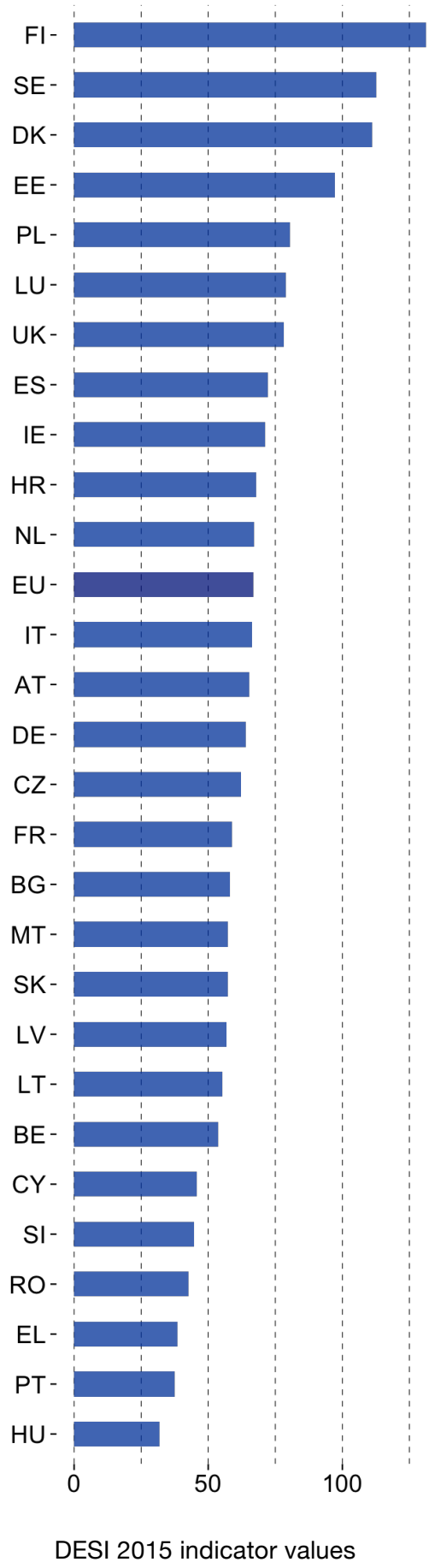
Electronic communications market indicators collected by Commission services, through National Regulatory Authorities, for the Communications Committee (COCOM)

Calculation:

no further calculation

DESI 2014: July 2013

DESI 2015: July 2014



DESI 2015 indicator values

1b2 Spectrum

Description:

Percentage of assigned spectrum out of the target to be harmonised at EU level

Breakdown:

Spectrum to be harmonised at EU level

Unit:

% of the target

Source:

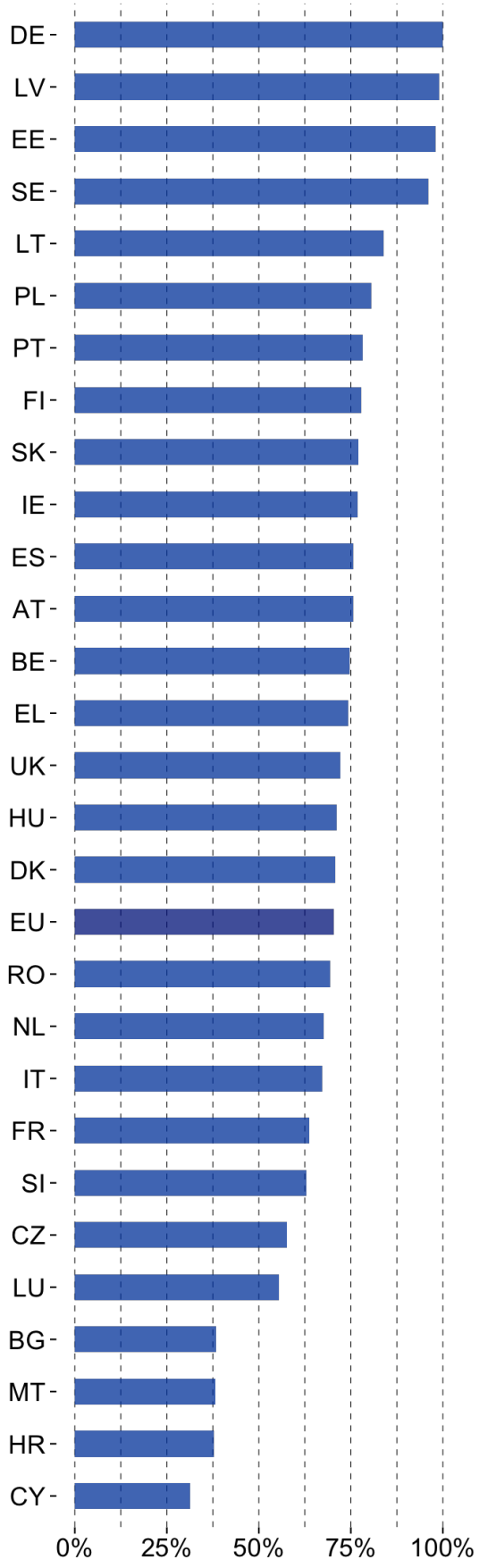
European Commission Services

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



DESI 2015 indicator values

1c1 NGA Coverage

Description:

Households covered by NGA broadband

Breakdown:

All households

Unit:

% households

Source:

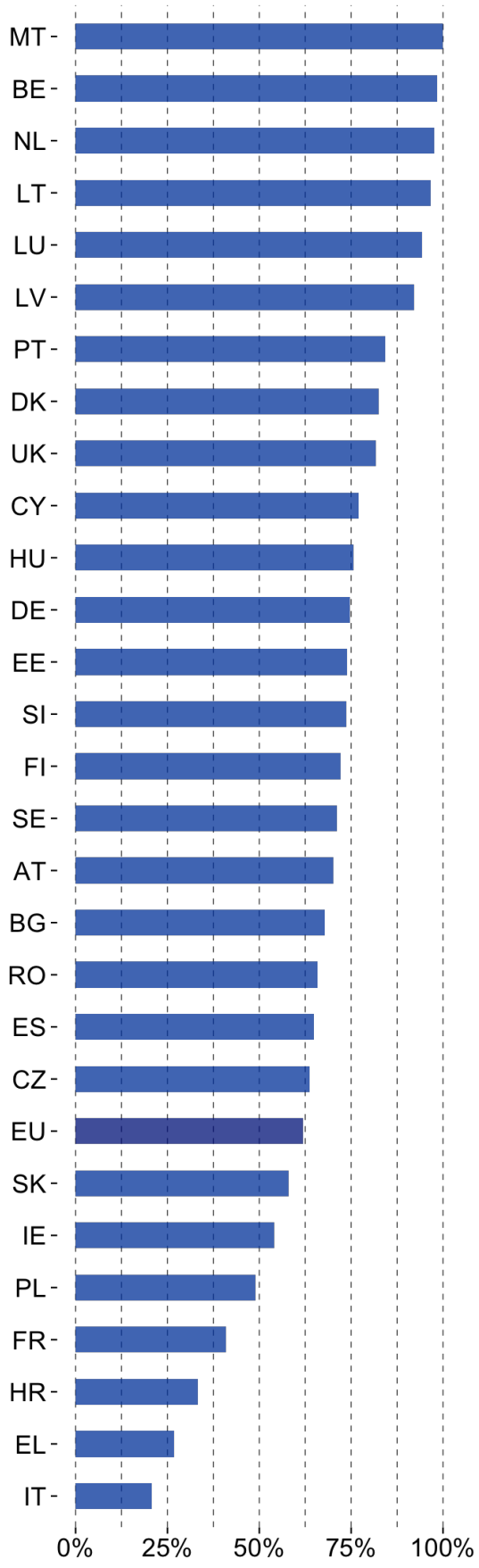
Broadband coverage in Europe, studies for the EC by Point Topic (2011-2012 figures, SMART 2011/0027 and 2012/0035) and IHS and Valdani, Vicari & Associati (2013 figures, SMART 2013/0054)

Calculation:

no further calculation

DESI 2014: December 2013

DESI 2015: December 2014



DESI 2015 indicator values

1c2 Subscriptions to Fast BB

Description:

Share of fixed broadband subscriptions >= 30 Mbps

Breakdown:

All fixed BB subscriptions

Unit:

% of subscriptions >= 30Mbps

Source:

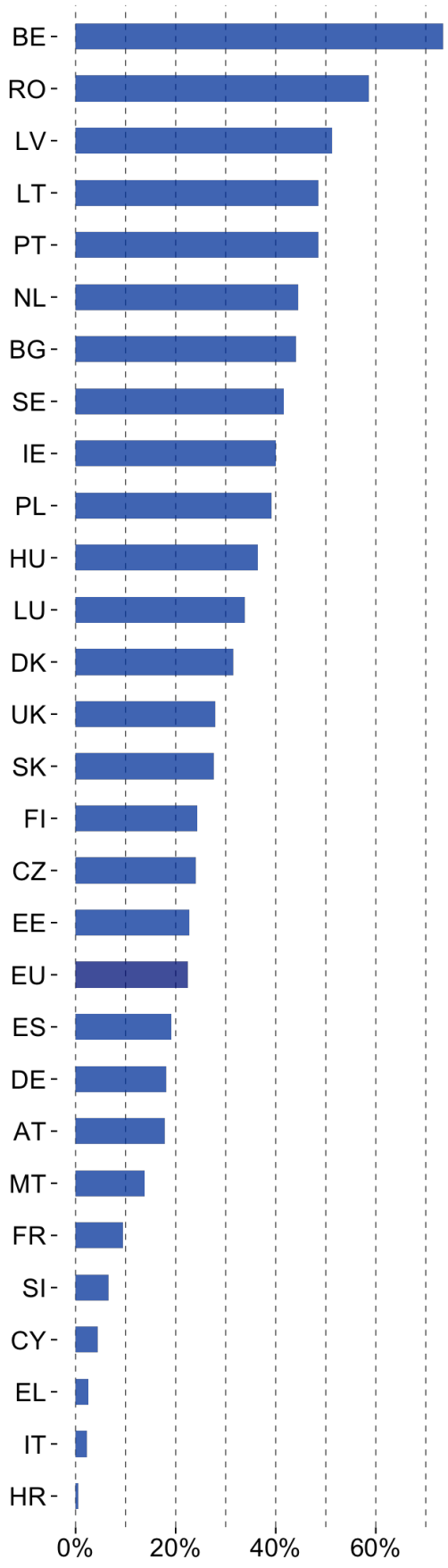
Electronic communications market indicators collected by Commission services, through National Regulatory Authorities, for the Communications Committee (COCOM)

Calculation:

no further calculation

DESI 2014: July 2013

DESI 2015: July 2014



DESI 2015 indicator values

1d1 Fixed BB Price

Description:

Monthly cost of the least expensive fixed broadband subscription with speed of 12 to 30 Mbps

Breakdown:

All standalone Fixed Broadband Internet Access offers

Unit:

Percentage of individual gross income (EUR PPP)

Source:

Access cost (A): Broadband Internet Access Cost (BIAC), annual studies for the EC realised by Van Dijk.

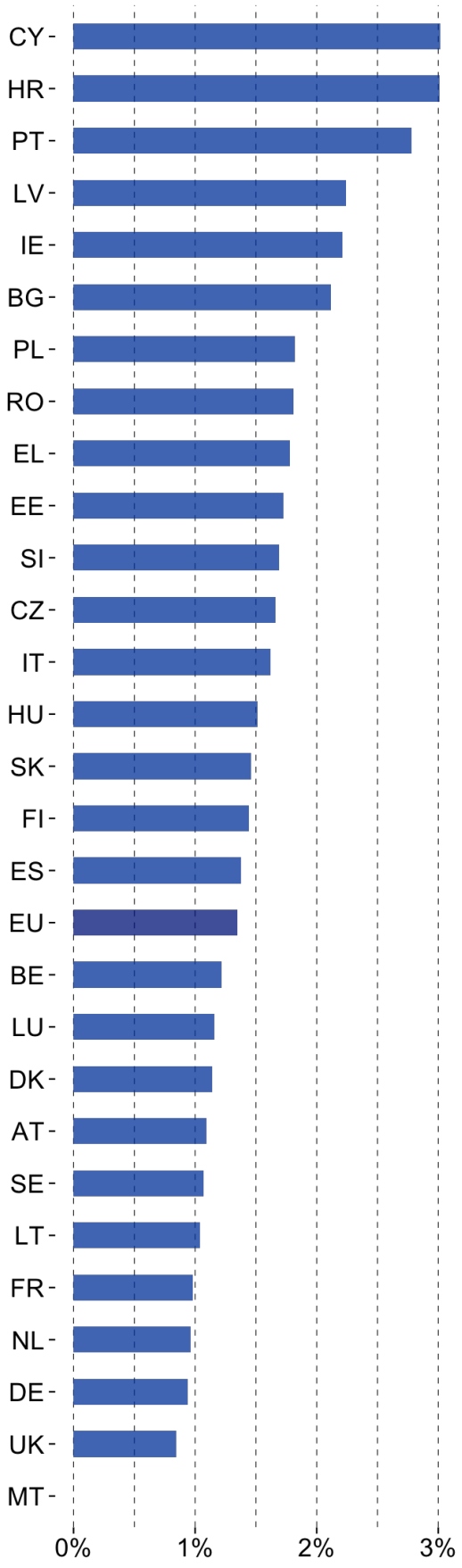
Income (B): Real adjusted gross disposable income of households per capita (Eurostat: tec00113)

Calculation:

Indicator = (A*12)/B

DESI 2014: Access cost: 2013; Income: 2013

DESI 2015: Access cost: 2014; Income: 2013



DESI 2015 indicator values

2a1 Internet Users

Description:

Individuals whose frequency of Internet access is at least once a week

Breakdown:

All Individuals (aged 16-74)

Unit:

% individuals

Source:

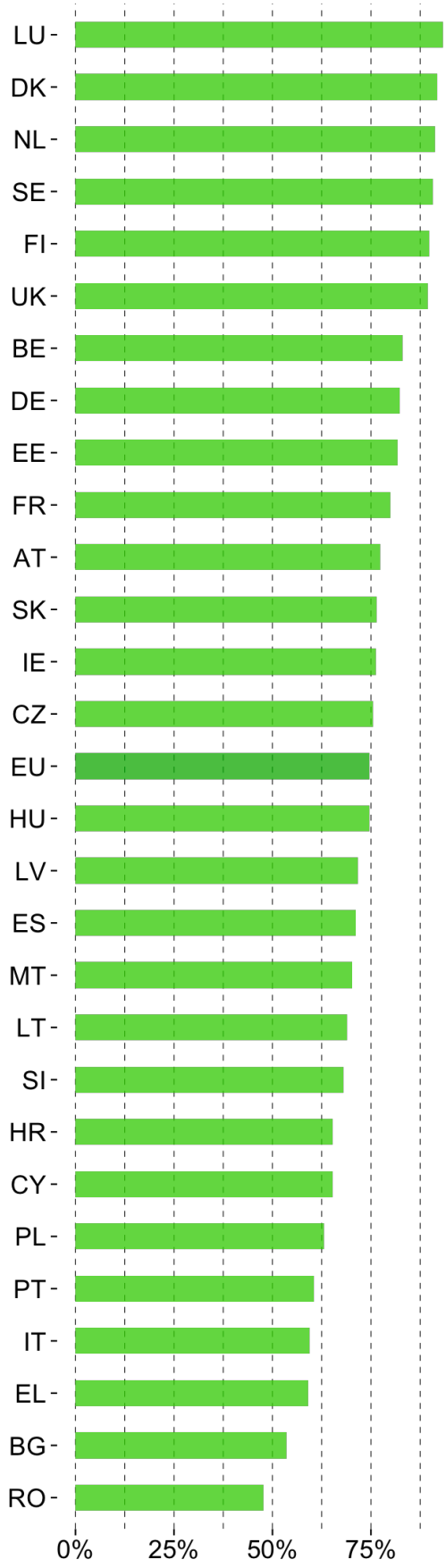
Eurostat - Community survey on ICT usage in Households and by Individuals

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



DESI 2015 indicator values

2a2 Basic Digital Skills

Description:

Individuals with basic digital skills

Breakdown:

All Individuals (aged 16-74)

Unit:

% individuals who used Internet in the last 3 months

Source:

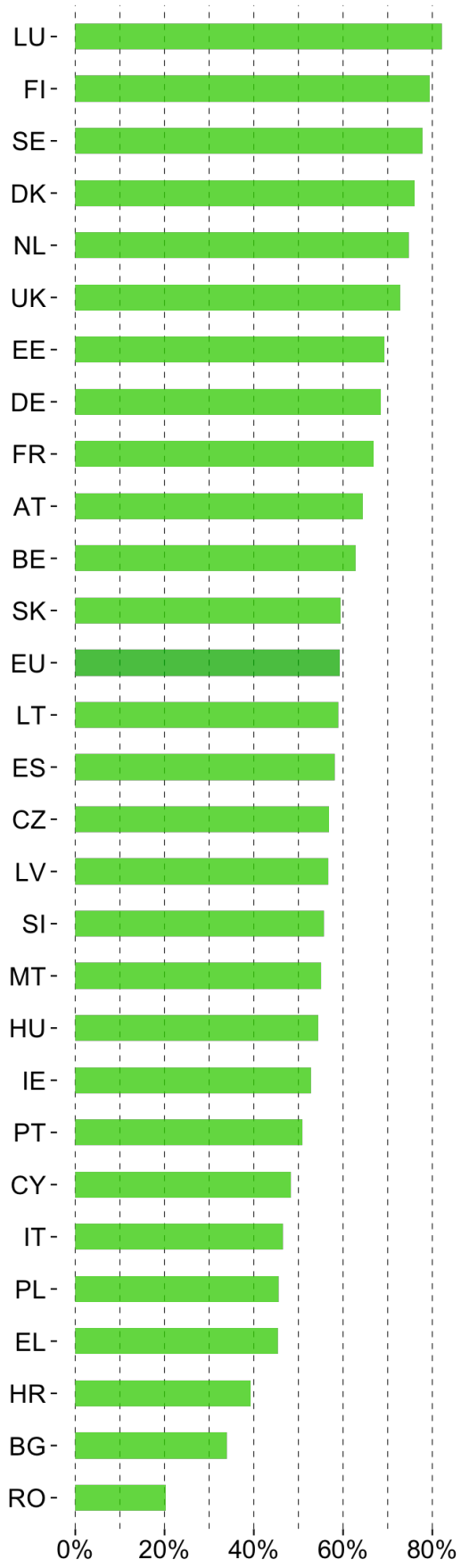
Pilot work carried out by DG CONNECT/F4 in relation to action 62 of the Digital Agenda to propose "EU-wide indicators of digital competence". These indicators have been piloted on the 2012 microdata from the Eurostat community survey on ICT usage by Households/Individuals. It is proposed for regular implementation starting with the 2015 survey.

Calculation:

no further calculation

DESI 2014: 2012

DESI 2015: 2014



DESI 2015 indicator values

2b1 ICT Specialists

Description:

Persons Employed with ICT Specialist Skills

Breakdown:

Employed individuals

Unit:

% employed individuals

Source:

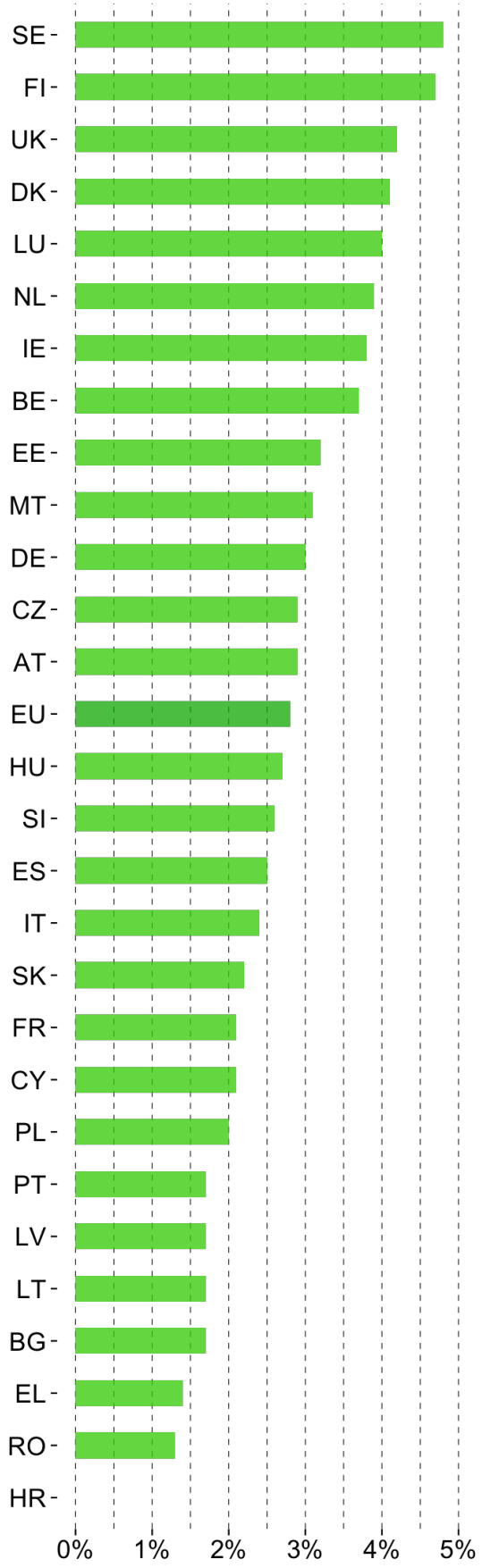
Eurostat - Labour Force Survey

Calculation:

no further calculation

DESI 2014: 2012

DESI 2015: 2012



DESI 2015 indicator values

2b2 STEM Graduates

Description:

Science and technology graduates

Breakdown:

All individuals 20 to 29 years old

Unit:

Graduates in STEM per 1000 individuals

Source:

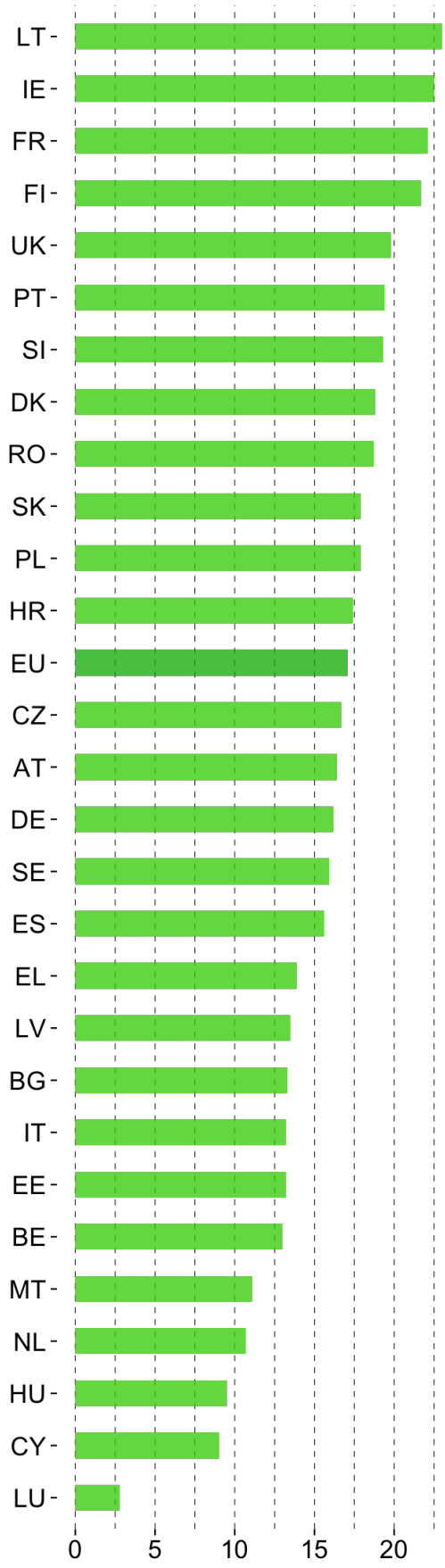
Eurostat (tps00188)

Calculation:

no further calculation

DESI 2014: 2012

DESI 2015: 2012



DESI 2015 indicator values

3a1 News

Description:

Individuals who used the Internet to read online news sites, newspapers or news magazines

Breakdown:

All Individuals (aged 16-74)

Unit:

% individuals who used Internet in the last 3 months

Source:

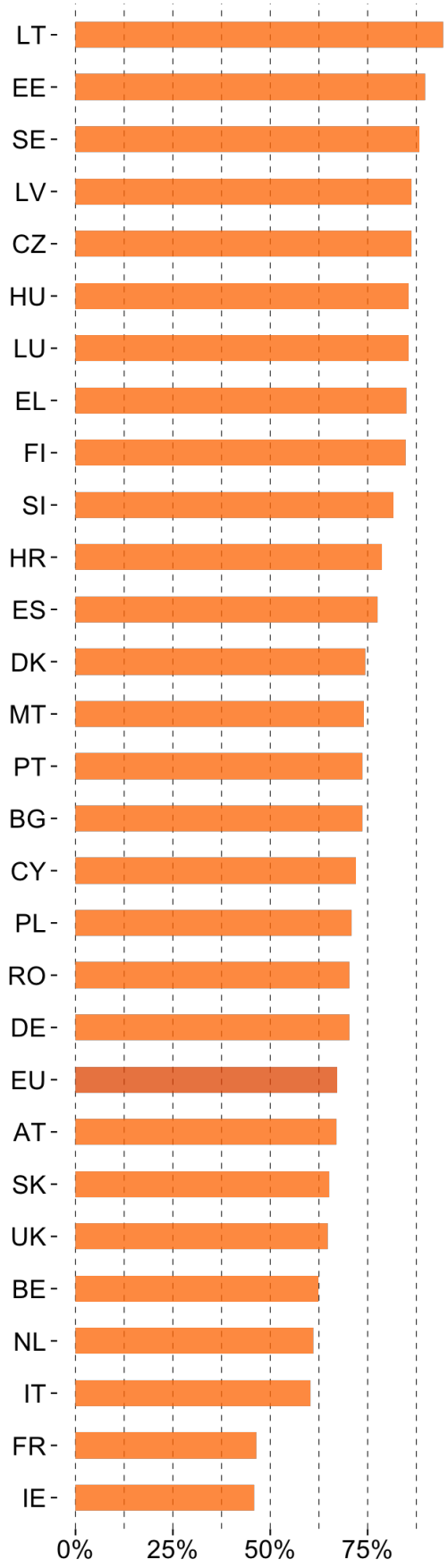
Eurostat - Community survey on ICT usage in Households and by Individuals

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



DESI 2015 indicator values

3a2 Music, Videos and Games

Description:

Individuals who used the Internet to play or download games, images, films or music

Breakdown:

All Individuals (aged 16-74)

Unit:

% individuals who used Internet in the last 3 months

Source:

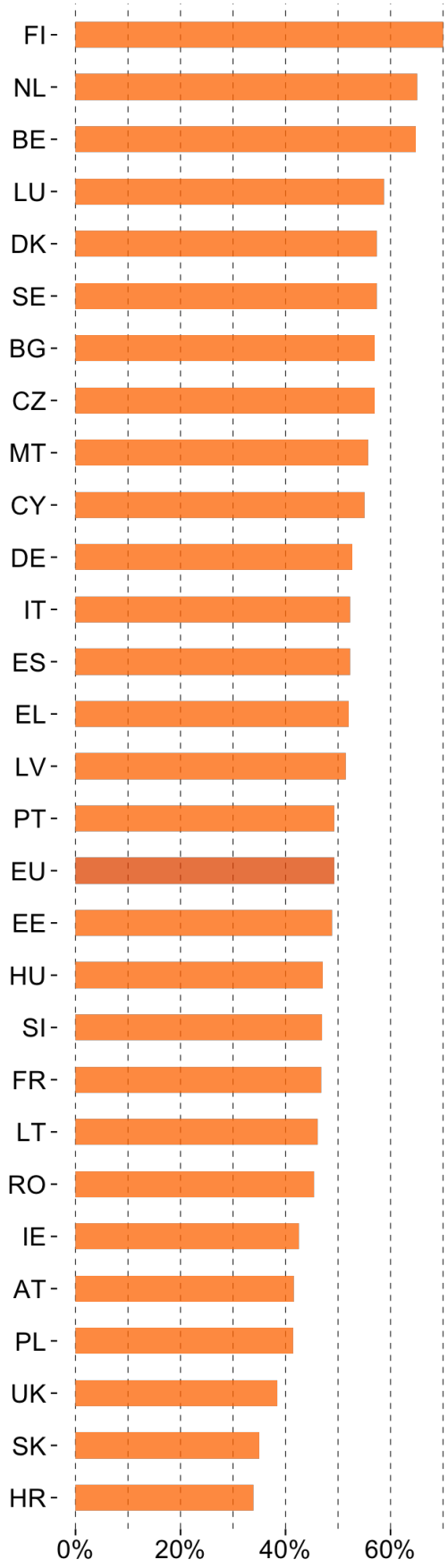
Eurostat - Community survey on ICT usage in Households and by Individuals

Calculation:

no further calculation

DESI 2014: 2012

DESI 2015: 2014



DESI 2015 indicator values

3a3 Video on Demand

Description:

Percentage of households subscribing to any form of Video on Demand

Breakdown:

Households that have a TV

Unit:

% households

Source:

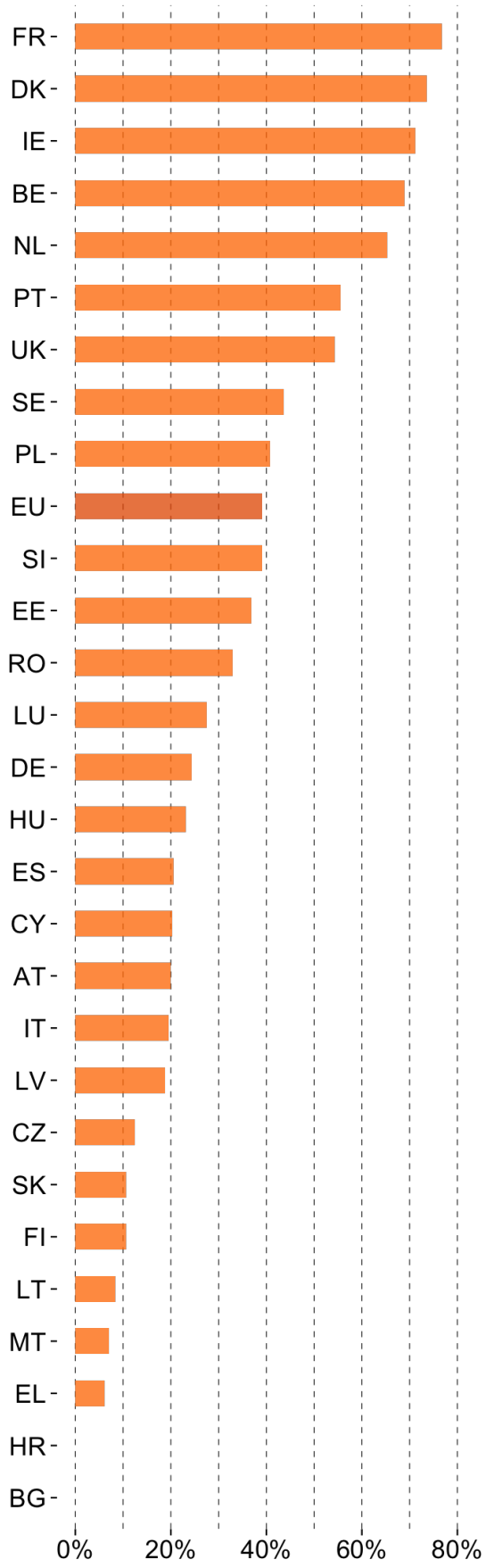
IHS Technology databases - TV Media Intelligence Service

Calculation:

EU average calculated as the average of the 26 MS (for which data is available) weighted by the number of households in each of them in 2013

DESI 2014: 2013

DESI 2015: 2013



DESI 2015 indicator values

3a4 IPTV

Description:

IPTV penetration

Breakdown:

Households that have a TV

Unit:

% households

Source:

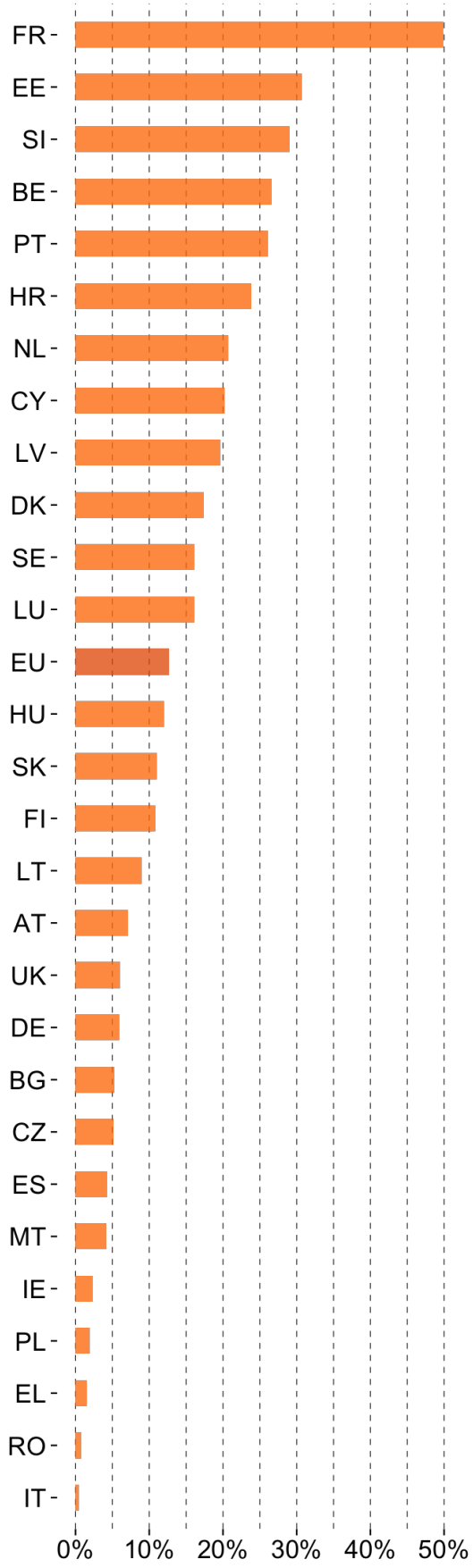
IHS Technology databases - TV Media Intelligence Service

Calculation:

EU average calculated as the average of the 28 MS weighted by the number of households in each of them in 2013

DESI 2014: 2013

DESI 2015: 2013



DESI 2015 indicator values

3b1 Video Calls

Description:

Individuals who used the Internet to make telephone or video calls

Breakdown:

All Individuals (aged 16-74)

Unit:

% individuals who used Internet in the last 3 months

Source:

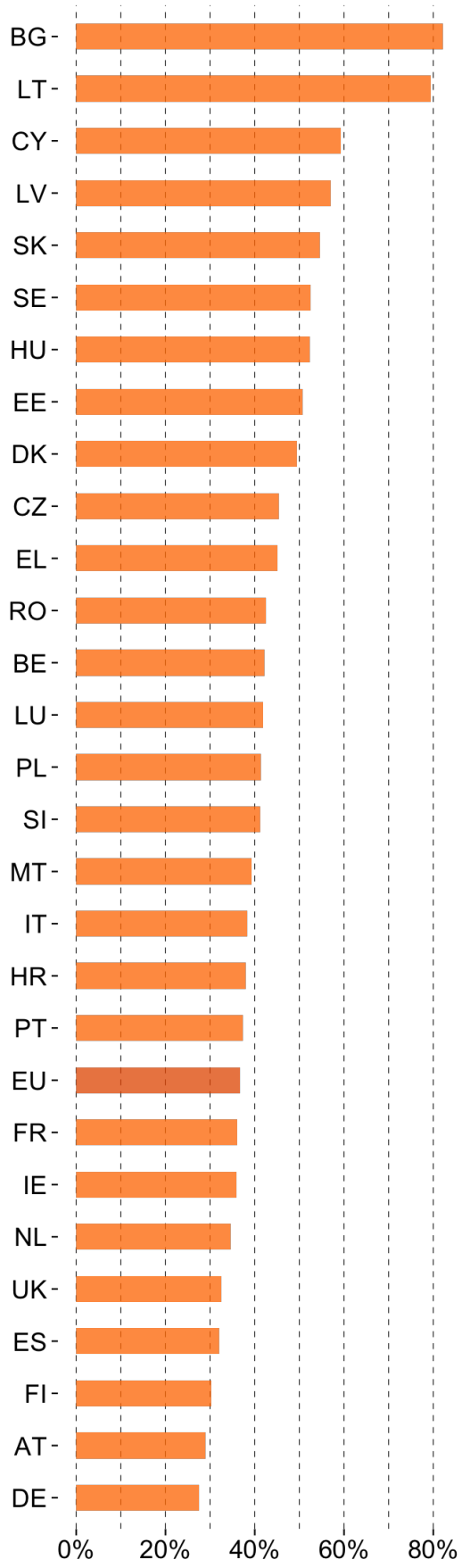
Eurostat - Community survey on ICT usage in Households and by Individuals

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



DESI 2015 indicator values

3b2 Social Networks

Description:

Individuals used the Internet to participate in social networks (create user profile, post messages or other contributions to facebook, twitter, etc.)

Breakdown:

All Individuals (aged 16-74)

Unit:

% individuals who used Internet in the last 3 months

Source:

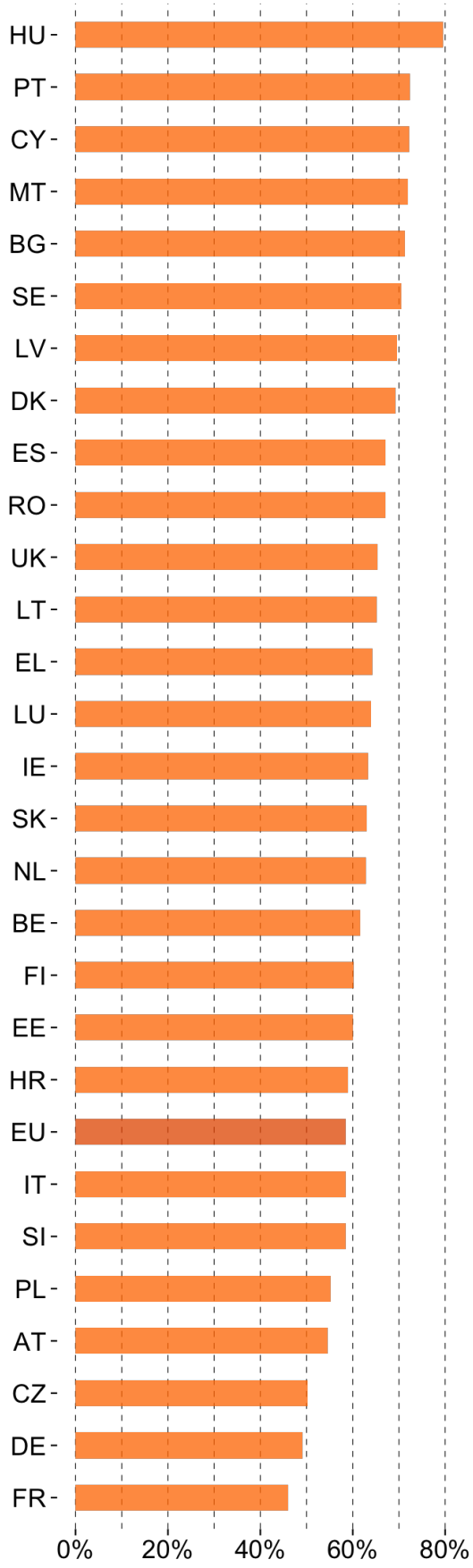
Eurostat - Community survey on ICT usage in Households and by Individuals

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



DESI 2015 indicator values

3c1 Banking

Description:

Individuals who used the Internet to use online banking

Breakdown:

All Individuals (aged 16-74)

Unit:

% individuals who used Internet in the last 3 months

Source:

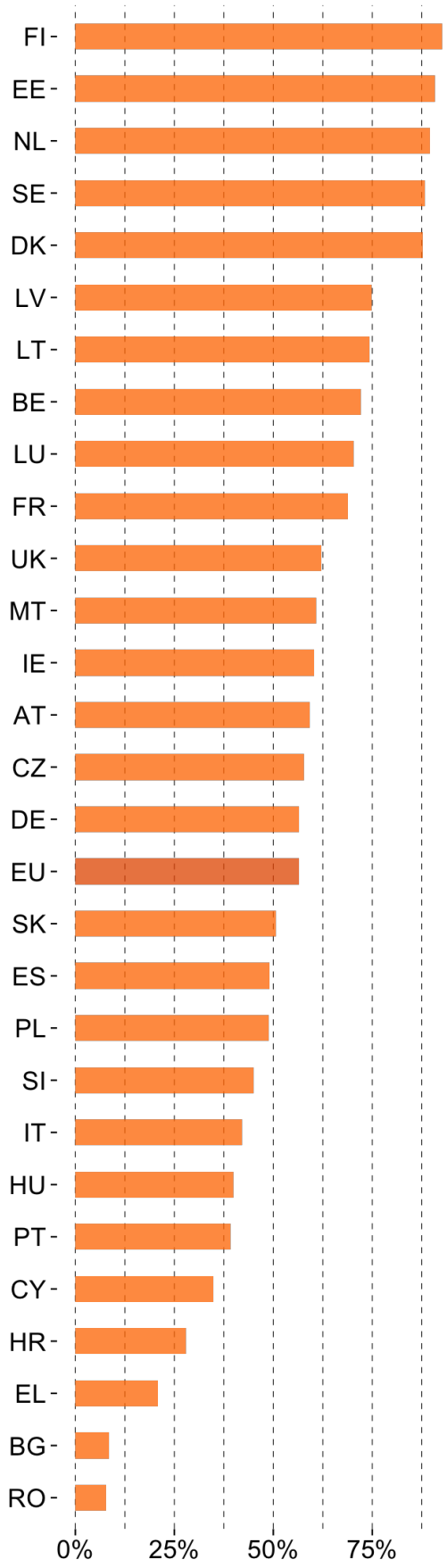
Eurostat - Community survey on ICT usage in Households and by Individuals

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



DESI 2015 indicator values

3c2 Shopping

Description:

Individuals who ordered goods or services online

Breakdown:

All Individuals (aged 16-74)

Unit:

% internet users (last year)

Source:

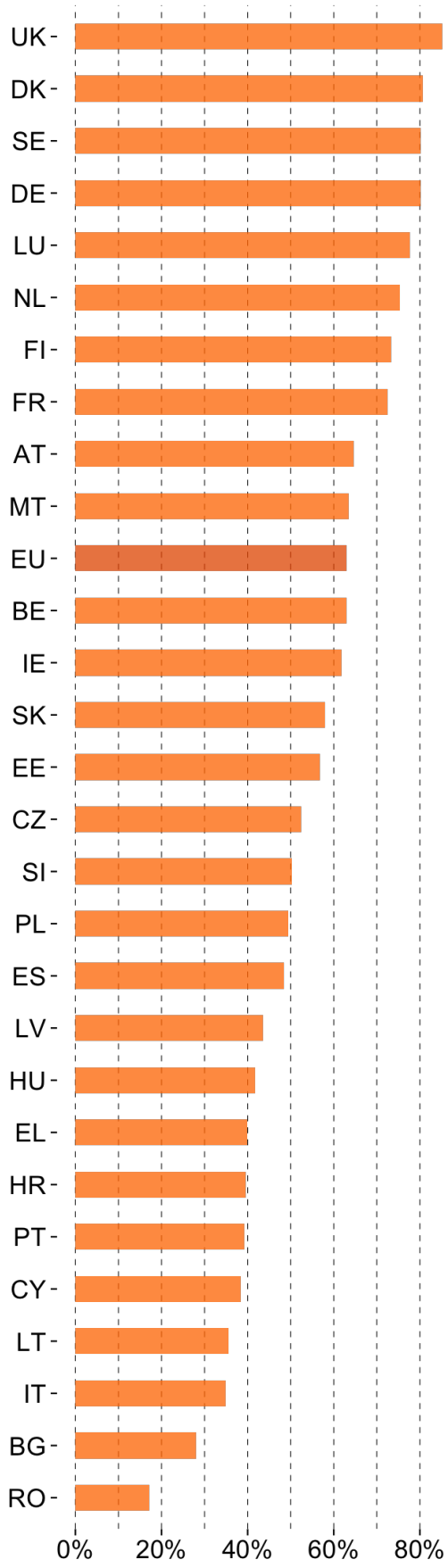
Eurostat - Community survey on ICT usage in Households and by Individuals

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



DESI 2015 indicator values

4a1 Electronic Information Sharing

Description:

Enterprises who have ERP software package to share information between different functional areas

Breakdown:

All enterprises (no financial sector, 10+ employees)

Unit:

% enterprises

Source:

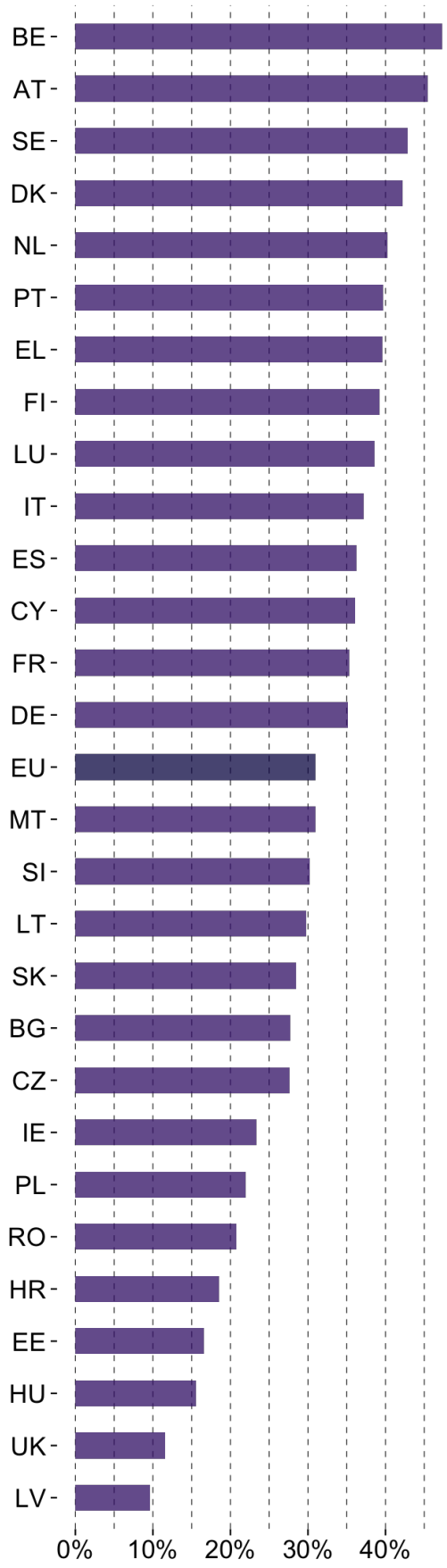
Eurostat - Community survey on ICT usage and eCommerce in Enterprises

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



DESI 2015 indicator values

4a2 RFID

Description:

Enterprises using Radio Frequency Identification (RFID) technologies for after sales product identification or as part of the production and service delivery

Breakdown:

All enterprises (no financial sector, 10+ employees)

Unit:

% enterprises

Source:

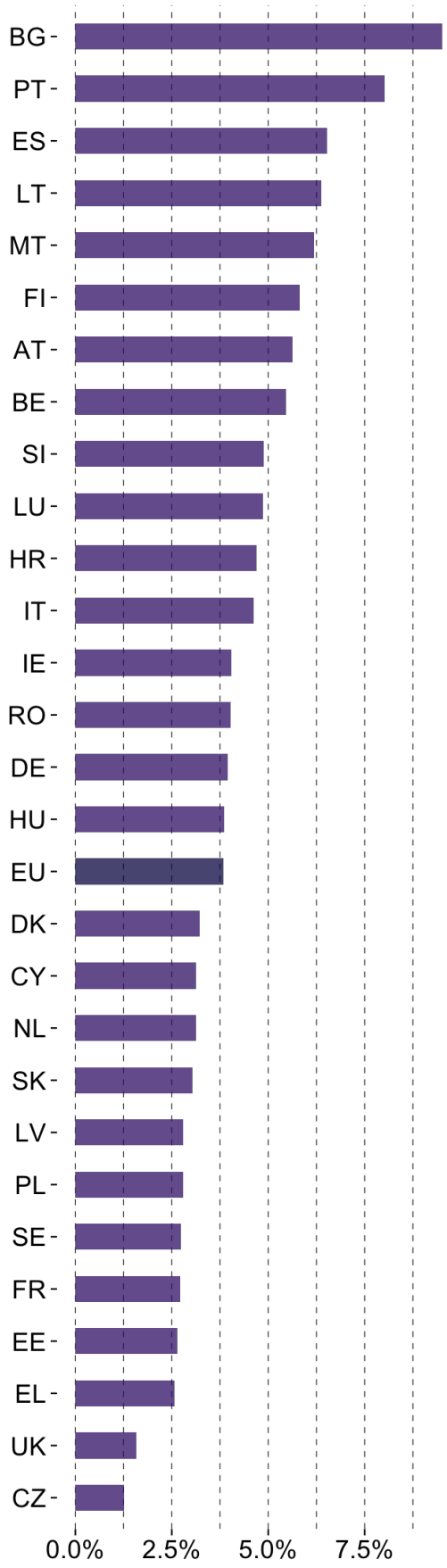
Eurostat - Community survey on ICT usage and eCommerce in Enterprises

Calculation:

no further calculation

DESI 2014: 2011 (e_rfpsas)

DESI 2015: 2014



DESI 2015 indicator values

4a3 Social Media

Description:

Enterprises that use two or more types of social media

Breakdown:

All enterprises (no financial sector, 10+ employees)

Unit:

% enterprises

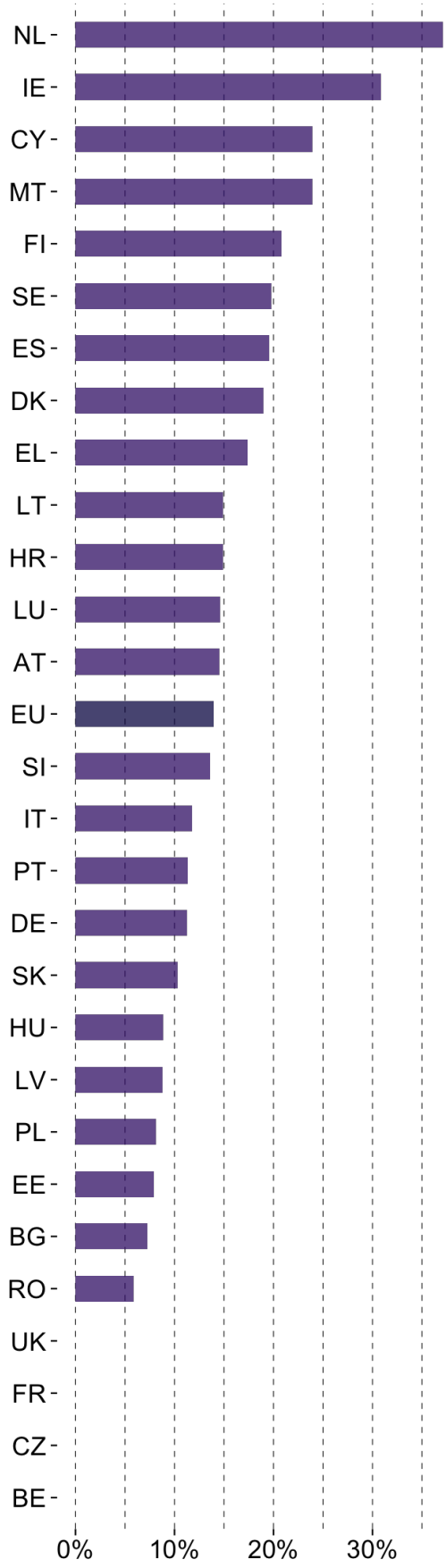
Source:

Eurostat - Community survey on ICT usage and eCommerce in Enterprises

Calculation: no further calculation

DESI 2014: 2013

DESI 2015: 2014



DESI 2015 indicator values

4a4 eInvoices

Description:

Enterprises sending e-invoices suitable for automatic processing

Breakdown:

All enterprises (no financial sector, 10+ employees)

Unit:

% enterprises

Source:

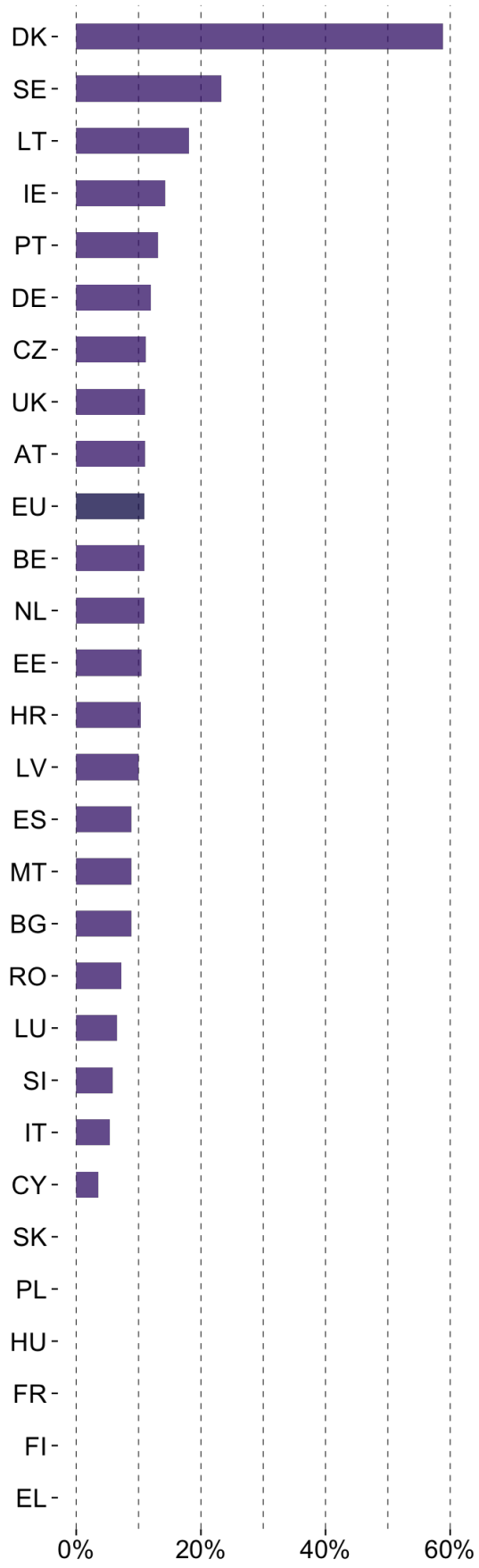
Eurostat - Community survey on ICT usage and eCommerce in Enterprises

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



DESI 2015 indicator values

4a5 Cloud

Description:

Enterprises that buy Cloud Computing services of medium-high sophistication

Breakdown:

All enterprises (no financial sector, 10+ employees)

Unit:

% enterprises

Source:

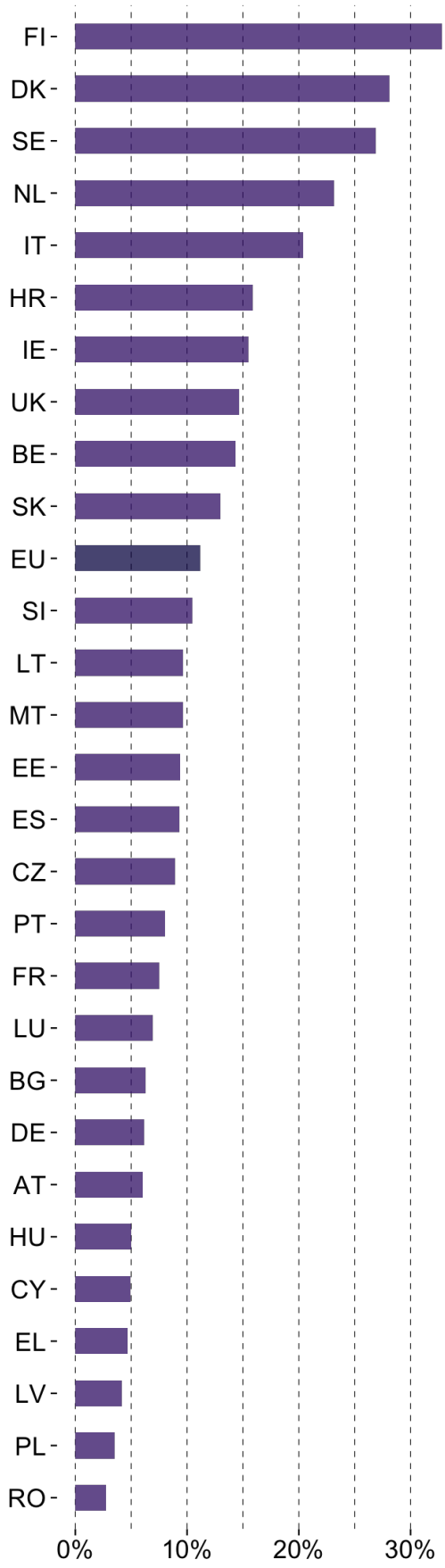
Eurostat - Community survey on ICT usage and eCommerce in Enterprises

Calculation:

no further calculation

DESI 2014: not included

DESI 2015: 2014



DESI 2015 indicator values

4b1 SMEs Selling Online

Description:

Enterprises selling online (at least 1% of turnover)

Breakdown:

SMEs (no financial sector, 10-249 employees)

Unit:

% enterprises

Source:

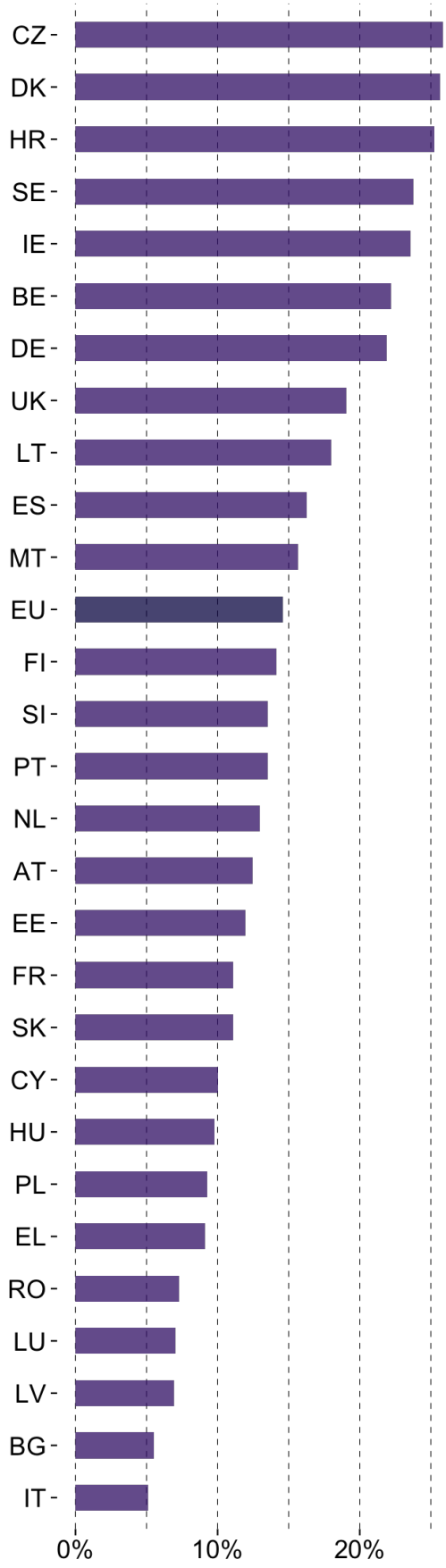
Eurostat - Community survey on ICT usage and eCommerce in Enterprises

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



DESI 2015 indicator values

4b2 eCommerce Turnover

Description:

Enterprises' total turnover from e-commerce

Breakdown:

SMEs (no financial sector, 10-249 employees)

Unit:

% turnover

Source:

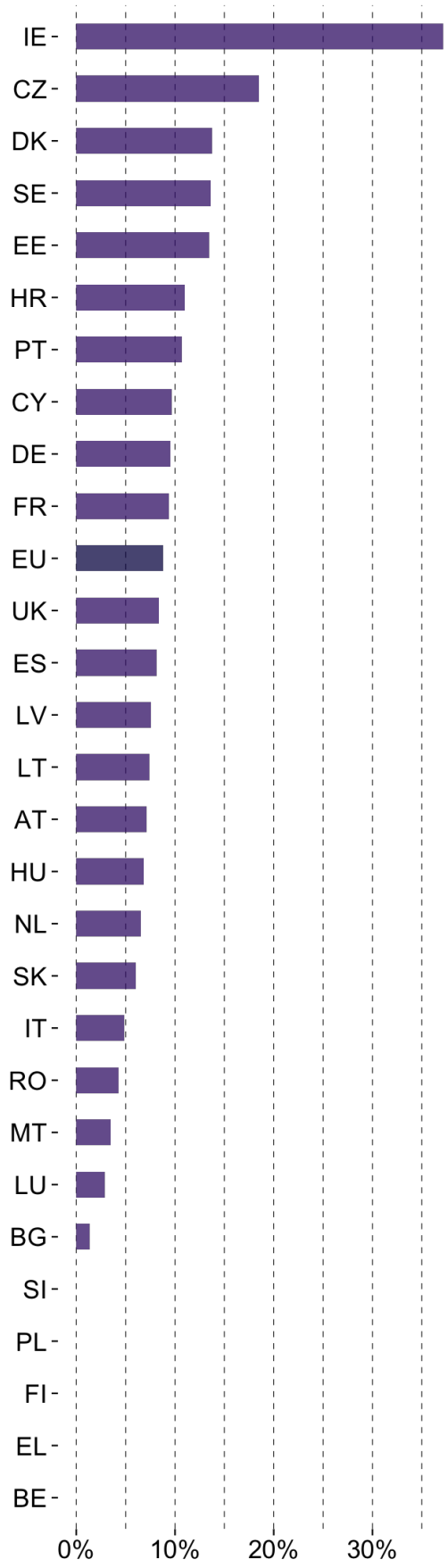
Eurostat - Community survey on ICT usage and eCommerce in Enterprises

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



DESI 2015 indicator values

4b3 Selling Online Cross-border

Description:

Enterprises that did electronic sales to other EU countries

Breakdown:

SMEs (no financial sector, 10-249 employees)

Unit:

% enterprises

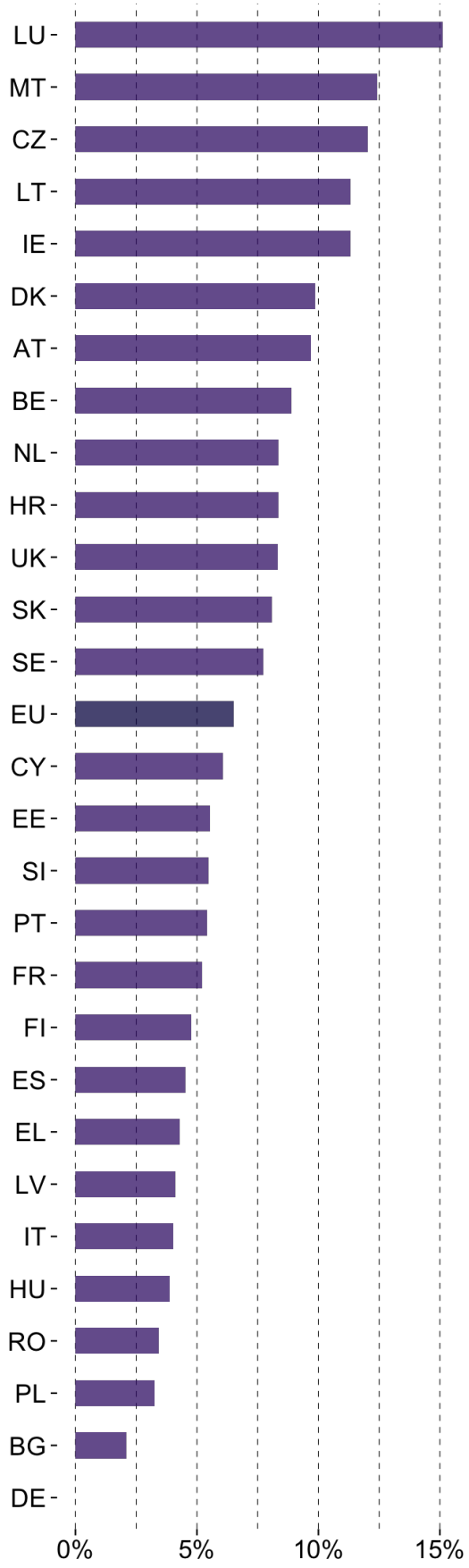
Source:

Eurostat - Community survey on ICT usage and eCommerce in Enterprises

Calculation: no further calculation

DESI 2014: 2013

DESI 2015: 2013



DESI 2015 indicator values

5a1 eGovernment Users

Description:

Individuals sending filled forms to public authorities, over the internet, last 12 months

Breakdown:

All Individuals (aged 16-74)

Unit:

% internet users (last year)

Source:

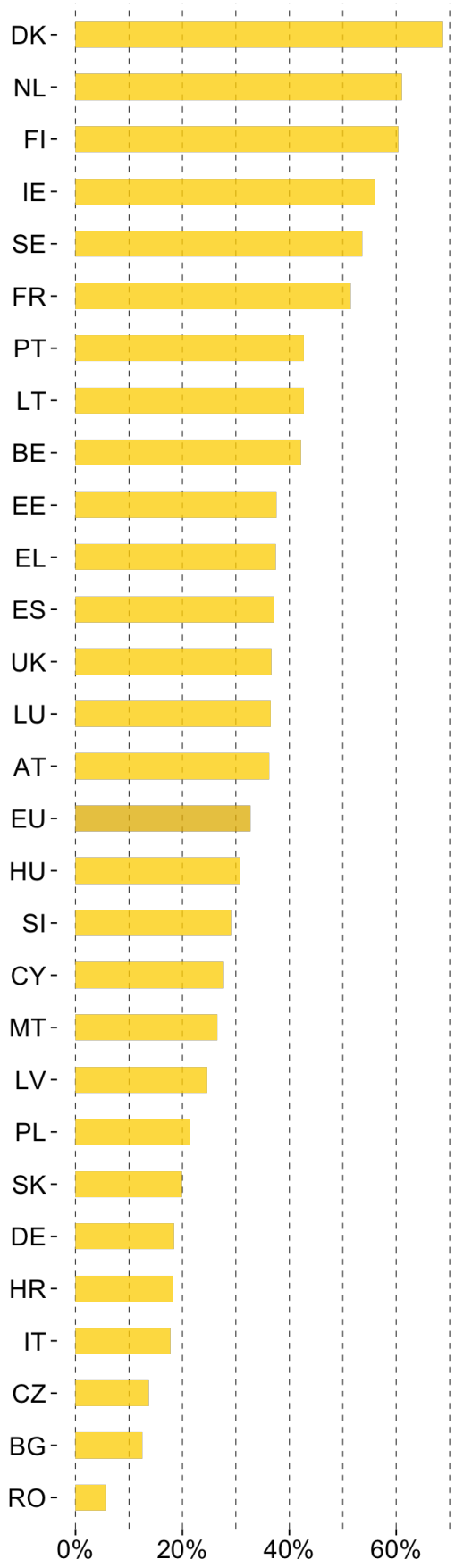
Eurostat - Community survey on ICT usage in Households and by Individuals

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



DESI 2015 indicator values

5a2 Pre-filled Forms

Description:

Amount of data that is pre-filled in Public Services' online forms (Authentic sources Key Enabler indicator of eGovernment benchmark)

Breakdown:

Services assessed in the eGovernment Benchmark

Unit:

Score (0 to 100)

Source:

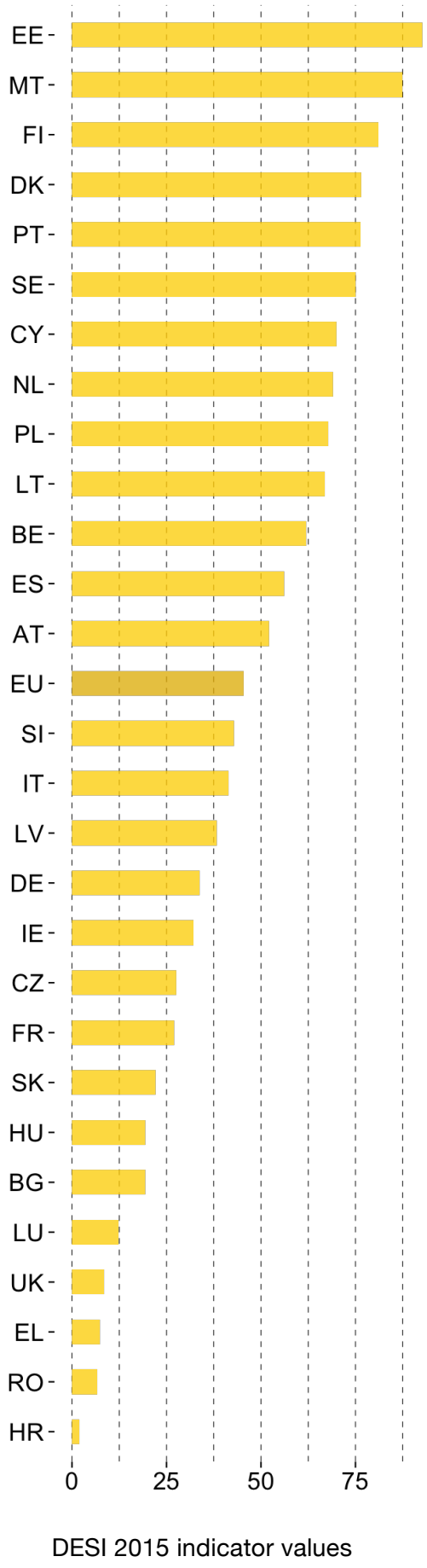
eGovernment Benchmark

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



5a3 Online Service Completion

Description:

Share of the steps in a Public Service life event that can be completed online (Online availability sub-indicator for User centricity of the eGovernment benchmark)

Breakdown:

Services assessed in the eGovernment Benchmark

Unit:

Score (0 to 100)

Source:

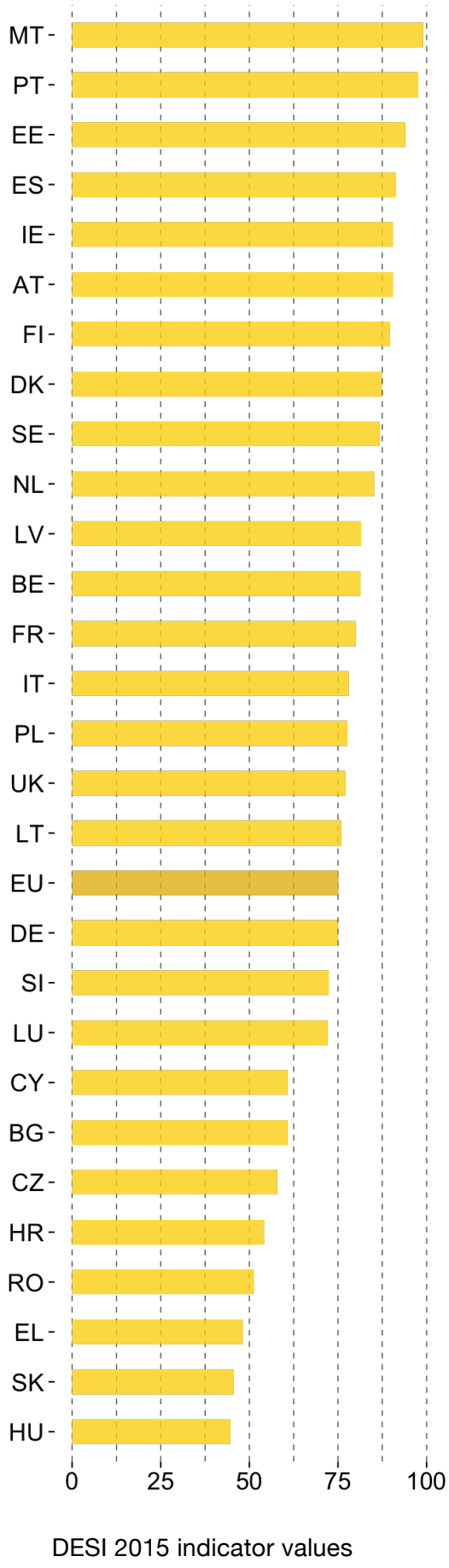
eGovernment Benchmark

Calculation:

no further calculation

DESI 2014: 2013

DESI 2015: 2014



5a4 Open Data

Description:

Score in the European PSI Scoreboard measuring the status of Open Data and PSI re-use throughout the EU

Breakdown:

Aggregate score

Unit:

Score (0 to 700)

Source:

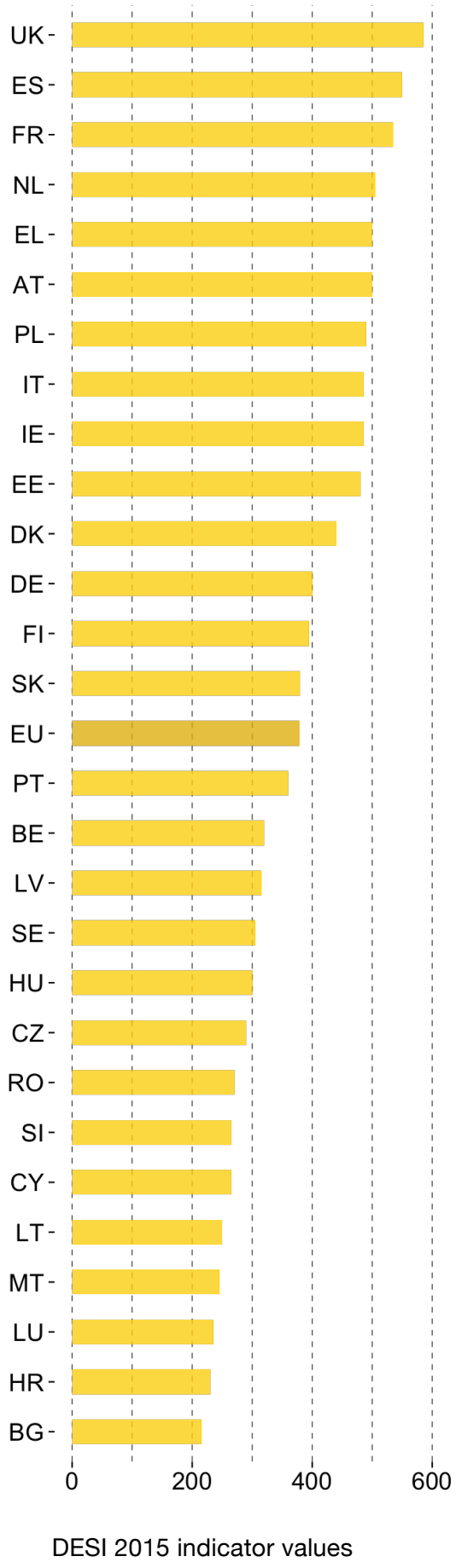
European PSI Scoreboard

Calculation:

EU average calculated as the simple average of the 28 MS

DESI 2014: not included

DESI 2015: December 2014



5b1 Medical Data Exchange

Description:

GPs using electronic networks to exchange medical data with other health care providers and professionals

Breakdown:

All General Practitioners

Unit:

% General Practitioners

Source:

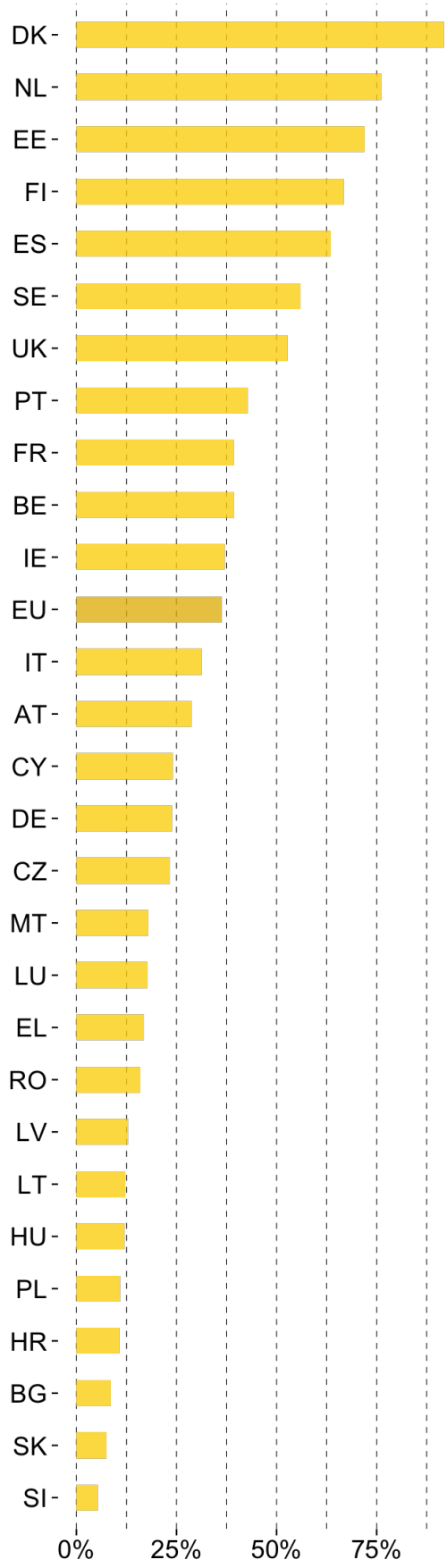
Benchmarking Deployment of eHealth among General Practitioners

Calculation:

EU average calculated as the average of the 28 MS weighted by their population in 2013

DESI 2014: 2013

DESI 2015: 2013



DESI 2015 indicator values

5b2 ePrescription

Description:

GPs using electronic networks to transfer prescriptions to pharmacists

Breakdown:

All General Practitioners

Unit:

% General Practitioners

Source:

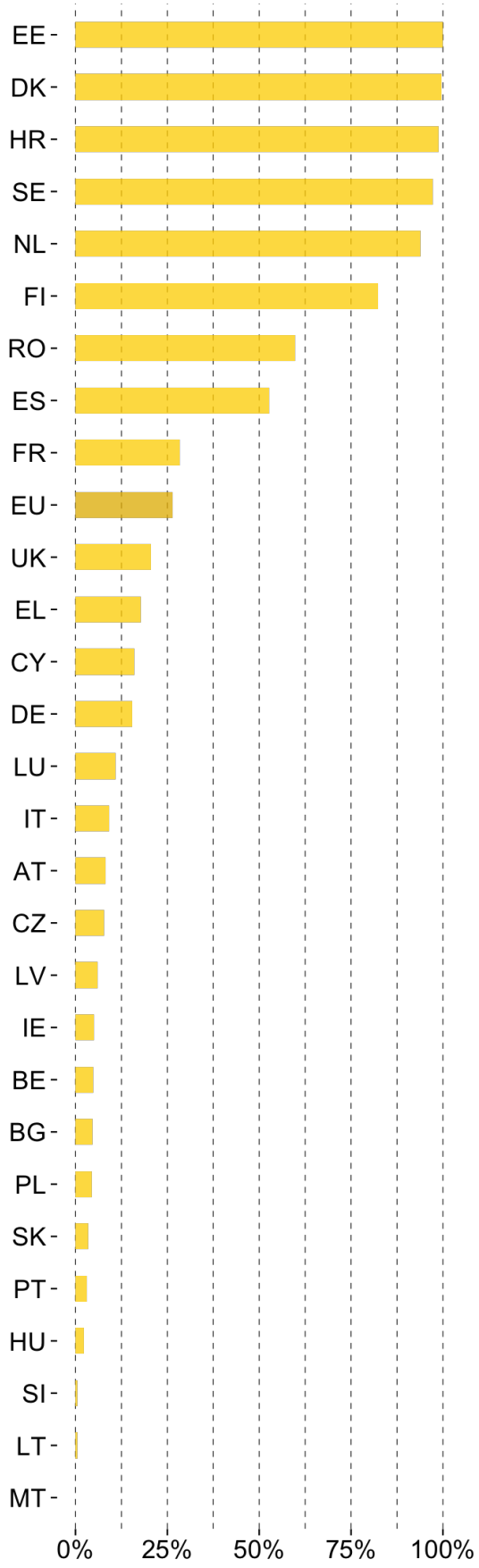
Benchmarking Deployment of eHealth among General Practitioners

Calculation:

EU average calculated as the average of the 28 MS weighted by their population in 2013

DESI 2014: 2013

DESI 2015: 2013



DESI 2015 indicator values