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**Methodological note**

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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"<sup>1</sup>. The data included in the index were mostly collected by the European Commission services (DG CNECT, Eurostat) and by ad-hoc studies launched by the Commission services.

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<sup>1</sup><http://www.oecd.org/els/soc/handbookonconstructingcompositeindicatorsmethodologyanduserguide.htm>

## 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.

Dimension	Sub-dimension	Indicator
1 Connectivity	1a Fixed Broadband	1a1 Fixed Broadband Coverage
		1a2 Fixed Broadband Take-up
	1b Mobile Broadband	1b1 Mobile Broadband Take-up
		1b2 4G coverage
		1b3 Spectrum
	1c Speed	1c1 NGA Coverage
		1c2 Subscriptions to Fast Broadband
1d Affordability	1d1 Fixed Broadband Price	
2 Digital Skills	2a Basic Skills and Usage	2a1 Internet Users
		2a2 At Least 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
	3b Communication	3b1 Video Calls
		3b2 Social Networks
	3c Transactions	3c1 Banking
		3c2 Shopping
4 Integration of Digital Technology	4a Business digitisation	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

**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. For methodological and data availability reasons, DESI 2017 presents structural changes when compared to DESI 2016. Such changes are described in section 2.6.

## **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), on how widely 4G services are available

(4G coverage) 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 percentage of internet users that watch Video on Demand (Video on Demand 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.

The Digital Public Services dimension is composed of one single sub-dimension.

### **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).

## 2.6 Changes compared to DESI 2016

The current publication of the DESI suffered some limited changes in comparison to the version published by the European Commission in 2016.

As for Connectivity, a new indicator on 4G coverage was added. This indicator measures the coverage of homes (the average of each mobile telecom operator's coverage within each country). It is to be noted that a different 4G coverage indicator was used in previous reports in the Digital Scoreboard. The old 4G indicator measured the overall coverage of operators, and it showed higher figures than the new indicator. In addition, a slightly revised methodology was used for the calculation of prices (1d1 Fixed Broadband Price). This resulted in changes in the historical data, which were re-stated.

In the Human capital dimension, the historical data were revised by Eurostat for the indicator 2b1 ICT specialists.

The Use of Internet dimension was affected by two changes. For the indicator 3a2 Music, video and games a slightly changed definition resulted in a break in series meaning that 2016 figures are not directly comparable with earlier years. In case of the indicator 3a3 Video on Demand, a new source (Eurostat) was used, showing the percentage of internet users (last 3 months) using Video on Demand services.

The Integration of Digital Technology dimension remained unchanged.

Regarding Digital Public Service, the indicator 5a4 Open data comes now from a new source (European Data Portal), and historical data were replaced for DESI 2016, too.

In addition, a limited number of historical data points were revised for other indicators, too. As a result of the above changes, the rankings for the previous years have slightly changed.

## 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 Data updates and corrections

Updates and corrections are part of the lifecycle and nature of statistical data. It is typical that the values for one indicator suffer small amendments and only stabilise completely months or even years after the indicator was originally computed. This is the case with a significant number of indicators used in the construction of the DESI.

At each publication, historical data are also reviewed to accommodate such changes. It is to be noted that the current report takes account of changes notified to the European Commission before 6 February 2017. Any modification made after this date will be included in the next report, which is expected in 2018.

### 3.3 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<sup>2</sup>.

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.

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<sup>2</sup> In DESI there is one indicator with negative direction: 1d1 Fixed BB Price.

Indicator	Unit	Min	Max
<b>1a1 Fixed BB Coverage</b>	% households	80%	100%
<b>1a2 Fixed BB Take-up</b>	% households	50%	100%
<b>1b1 Mobile BB Take-up</b>	Subscribers per 100 people	25	150
<b>1b2 4G coverage</b>	% households	0%	100%
<b>1b2 Spectrum</b>	% of the target	25%	100%
<b>1c1 NGA Coverage</b>	% households	0%	100%
<b>1c2 Subscriptions to Fast BB</b>	% of subscriptions >= 30Mbps	0%	100%
<b>1d1 Fixed BB Price</b>	Percentage of individual gross income (EUR PPP)	0%	4%
<b>2a1 Internet Users</b>	% individuals	40%	100%
<b>2a2 Basic Digital Skills</b>	% individuals	0%	100%
<b>2b1 ICT Specialists</b>	% individuals	0%	7%
<b>2b2 STEM Graduates</b>	Graduates in STEM per 1000 individuals (20-29 yo)	0	40
<b>3a1 News</b>	% individuals who used Internet in the last 3 months	33%	100%
<b>3a2 Music, Videos and Games</b>	% individuals who used Internet in the last 3 months	50%	100%
<b>3a3 Video on Demand</b>	% individuals who used Internet in the last 3 months	0%	60%
<b>3b1 Video Calls</b>	% individuals who used Internet in the last 3 months	20%	100%
<b>3b2 Social Networks</b>	% individuals who used Internet in the last 3 months	40%	100%
<b>3c1 Banking</b>	% individuals who used Internet in the last 3 months	0%	100%
<b>3c2 Shopping</b>	% internet users (last year)	0%	100%
<b>4a1 Electronic Information Sharing</b>	% enterprises	0%	60%
<b>4a2 RFID</b>	% enterprises	0%	15%
<b>4a3 Social Media</b>	% enterprises	0%	50%
<b>4a4 eInvoices</b>	% enterprises	0%	50%
<b>4a5 Cloud</b>	% enterprises	0%	50%
<b>4b1 SMEs Selling Online</b>	% of SMEs	0%	33%
<b>4b2 eCommerce Turnover</b>	% turnover	0%	33%
<b>4b3 Selling Online Cross-border</b>	% of SMEs	0%	25%

<b>5a1 eGovernment Users</b>	% internet users (last year)	0%	80%
<b>5a2 Pre-filled Forms</b>	Score (0 to 100)	0	100
<b>5a3 Online Service Completion</b>	Score (0 to 100)	40	100
<b>5a4 Open Data</b>	% of the maximum score	0	100%

**Table 2.** Minima and Maxima used in indicator normalisation

### 3.4 Imputation of missing observations

Some indicators presented missing observations for some countries. Values for those observations were estimated using different methodologies. If a value from a previous year was available, this value was used. In certain indicators (e.g. 4a4 eInvoices and 4a5 Cloud) 2015 data was missing for several countries, but 2014 and 2016 values were available. In these cases the 2015 values were estimated as the average of 2014 and 2016 data. In some other cases, more recent data was used to estimate data points for earlier years. For indicators, where no time series were available for all the four years presented in the current report, the missing years were estimated based on the data for the available years.

In DESI 2017, less than 0.1 % of all observations were imputed. As for the whole data set (DESI 2014-2017) imputations concern less than 2 % of data points.

### 3.5 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 3 presents the overall weights attributed to the main DESI dimensions, which reflect the EU's digital policy priorities.

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

**Table 3.** 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 4<sup>3</sup>.

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%. There is only one sub-dimension under the *Digital Public Services* dimension: *eGovernment* is weighted at 100%.

Sub-Dimension	Weight
<b>1 Connectivity</b>	
<b>1a Fixed Broadband</b>	33%
<b>1b Mobile Broadband</b>	22%
<b>1c Speed</b>	33%
<b>1d Affordability</b>	11%
<b>2 Human Capital</b>	
<b>2a Basic Skills and Usage</b>	50%
<b>2b Advanced skills and Development</b>	50%
<b>3 Use of Internet</b>	
<b>3a Content</b>	33%
<b>3b Communication</b>	33%
<b>3c Transactions</b>	33%
<b>4 Integration of Digital Technology</b>	

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<sup>3</sup> 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%.

4a Business digitization	60%
4b eCommerce	40%
<b>5 Digital Public Services</b>	
5a eGovernment	100%

**Table 4.** 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.

### 3.6 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.